Technical Report 505

HUMAN PERFORMANCE IN CONTINUOUS OPERATIONS: DESCRIPTION OF A SIMULATION MODEL AND USER'S MANUAL FOR EVALUATION OF PERFORMANCE DEGRADATION

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

User instructions and reference materials are presented for a computer simulation model which analyzes the PERFormance Effectiveness of Combat Troops (PERFECT). The model allows analysis of anticipated performance effectiveness when variables such as continuous time in battle, light level, enemy/friendly numerical ratio, enemy/friendly terrain advantage, amount of platooning, and amount of sleep permitted are varied alone or in combination.

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20. (continued)

The model is designed for interactive operation at a terminal by a user with no or minimum sophistication in computer science or computer use. The primary output of the model is tables of personnel effectiveness degradation by day, type of combat unit, and each of five "combat factors."

Along with interpretive guidance, step-by-step procedures are presented for the preparation of model data and for running the model.

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Man-Machine Interface in Integrated
Battlefield Control Systems

ARI Research Reports and Technical Reports are intended for sponsors of R&D tasks and for other research and military agencies. Any findings ready for implementation at the time of publication are presented in the last part of the Brief. Upon completion of a major phase of the task, formal recommendations for official action normally are conveyed to appropriate military agencies by briefing or Disposition Form.

FOREWORD

Night and continuous operations place new and unique demands on operating personnel. Effective doctrine and tactics cannot be formulated unless human capabilities and limitations in this environment are understood and accommodated through equipment aids, new operating procedures, and special training, as well as revised manning and rotation cycles.

This document represents the most recent product of ARI research on Human Performance in Continuous Operations. Earlier work has been published in the three volumes of Research Product 80-4. Volume I presents Guidelines to the military user on expected human performance capabilities during continuous combat. Volume II provides a Management Guide on how to minimize expected performance decrements during continuous operations. Volume III, Technical Supplement, depicts the technical aspects of the development and background data for the information contained in Volumes I and II, and describes the methods employed for predicting performance degradation. Together these volumes update and replace ARI Research Product 79-8, "Human Performance in Continuous Operations Guidelines," and Technical Report 386, which provided background data. The three volumes provide a body of general and highly specific information about the soldier's tasks on which degraded performance can be anticipated during continuous operations. This research report provides a description and user's manual for a computer simulation model which evaluates performance degradation during continuous operations. The computer model provides combat effectiveness data by processing the information embodied in the earlier volumes. The information provided in the earlier volumes and in this report will be useful to tactical planners and training specialists.

The research was conducted under Contract DAHC 19-77-C-0054, as part of Army Project 2Q163743A774, Man-Machine Interface in Integrated Battlefield Control System, FY 1978 Work Program. The research was supported by CACDA/CATRADA at Fort Leavenworth, Kansas, which was the TRADOC sponsor. Special thanks are due to Colonel Robert N. Morrison, Major Michael G. Jones, and Major Robert O. Livingston for their recommendations and cooperation.

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BRIEF

Requirement:

This simulation model was developed to aid in the understanding of human performance during night and continuous operations. The model was designed as a means of assessing the cumulative effect of many stress-producing variables on human performance during continuous combat. In addition, the model allows insight on the potential interaction between variables which affect combat performance.

Description:

This technical report is a description and user's manual for the computer simulation model PERFECT. PERFECT is a computer simulation model designed to analyze the PERFormance Effectiveness of Combat Troops. The model simulates degradation of combat effectiveness and stress buildup of ground combat troops during continuous operations. This model permits analysis of anticipated performance effectiveness when variables such as continuous time in battle, light level, enemy/friendly numerical ratio, enemy/friendly material ratio, enemy/friendly terrain advantage, amount of platooning and amount of sleep, are varied alone or in combination.

The model uses effectiveness values derived from ARI Research Product 80-4 (Vol 1), which presents guidelines on expected human performance capabilities during continuous operations, to yield estimates of performance indices and stress values. These estimates are given by type of unit, by composition of unit, by initial proficiency level of unit, by performance factor, by total operation of all units and by enemy/friendly strength ratios.

The model is designed for interactive operation at a terminal by a user with no or minimum sophistication in computer science.

Utilization:

As presently configured the model has utility for tactical planners and training specialists. The model can aid in the realization of training needs, doctrine needs, equipment needs, and tactical requirements. The model may also be used in conjunction with other war-gaming models. The model can be used as an "exercise" in planned training programs, as a means of demonstrating the importance of human performance parameters to mission success.

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CHAPTER I

INTRODUCTION AND OVERVIEW

This manual provides "How to do it" instructions for using a computer model which simulates the effectiveness degradation and stress buildup of ground combat troops during continuous operations. The model is named "PERFECT" for PERFormance Effectiveness of Combat Troops. Its objective is to process the detailed effectiveness data presented in the Guidelines--Human Performance in Continuous Operations, Volumes I and III (Siegel, et al., 1980) and to produce summarized effectiveness predictive curves for specified numbers and types of Army combat units during continuous operations. The approach permits an analyst to make computer runs under input parametric conditions which he selects, and to observe the effect of these conditions on the general effectiveness levels of the combat units involved. The model permits continuous operations to be simulated over periods of up to five days. It is hightly flexible and is designed to run from a small scale computer system terminal. For most applications, minimum input requirements are involved. Use of the model requires little, if any, knowledge of computer systems. Moreover, the model is designed to run quickly, i.e., to provide output on line with no noticeable time spent in waiting for calculations to be completed. This facilitates the performance of interactive "experiments" in which a set of "what if" questions may be answered.

Model Overview

A list of some of the major features of the PERFECT model is shown in Table 1.1. The simulation model is based on a series of manipulations of a four dimensional matrix of values of combat troops' effectiveness, as a function of the composition of the combat force, the mission (platoon action) sequence designated, and a series of parameter input values. In general, effectiveness levels will degrade as a function of time, but improve (increase) with sleep/rest (if sleep/rest is specified by the parameter inputs). Effectiveness also degrades with increasing stress level of the troops. This stress level, in turn, is a function of the value of several parameters including light level conditions, terrain advantage, squad proficiency levels, enemy/friendly personnel strength ratio, and enemy/friendly material strength ratio. Effectiveness also improves (i.e., is restored) when platooning is specified to replace designated combat units.

In order to gain a perspective of the scope or "size" of the model, it is helpful to observe the values selected for the maximum value of key variables. These are shown in Table 1.2. The model handles operations up to

Table 1.1

Summary of Features of Simulation Model

- Utilizes effectiveness values presented in the Guidelines--Human Performance in Continuous Operations, Volume III
- Incorporates stress buildup resulting from battle conditions and stress relief
- Flexible, understandable set of input parameters
- Programmed for computer interactive terminal operations
- Accomodates continuous operations of combat troops for up to five days duration
- Considers platooning (replacement) at the squad level
- Incorporates defensive and allows expansion to offensive operations
- Allows a variety of selectable output options
- Provides an effectiveness profile by combat unit type and by performance factor

Table 1.2

Principal Model Limits

Variable	Maximum Current Value
Days	5
Duty Positions	16
Type of Combat Units	9
Number of Units of Each Type	5
Factors	5
Types of Platoon Action	3

five days in duration. It considers a maximum of 16 duty positions and nine combat unit types (mechanized infantry, armor, etc.). The PERFECT model simulates three platoon actions for which data are currently available (see Guidelines) on the basis of five summary factors. The model is designed so that these limits can be expanded later, if desired, to simulate different scenarios and additional duty positions, combat unit types, factors, and platoon actions.

The model allows an analyst, using a computer terminal, to enter parameters, make input data changes, implement a simulation run, and receive an immediate report of results since computer response to each interaction takes only a few seconds. This capability makes practical a series of runs in which the selection of a subsequent run can be dependent on the results of prior runs.

Figure 1.1 presents a general flow diagram of the major steps which can be performed (or bypassed) when employing the model. Step-by-step terminal user's instructions follow in Chapter II and are supported by a full flow chart which is presented in Appendix A.

More specific detail about the functions, logic, processing, and calculations which the program performs are given in Appendix B. A flow chart of the program is presented in Appendix C. Appendices D and E present technical data relative to the model's content and Appendix F presents a list of the primary variables used in the model.

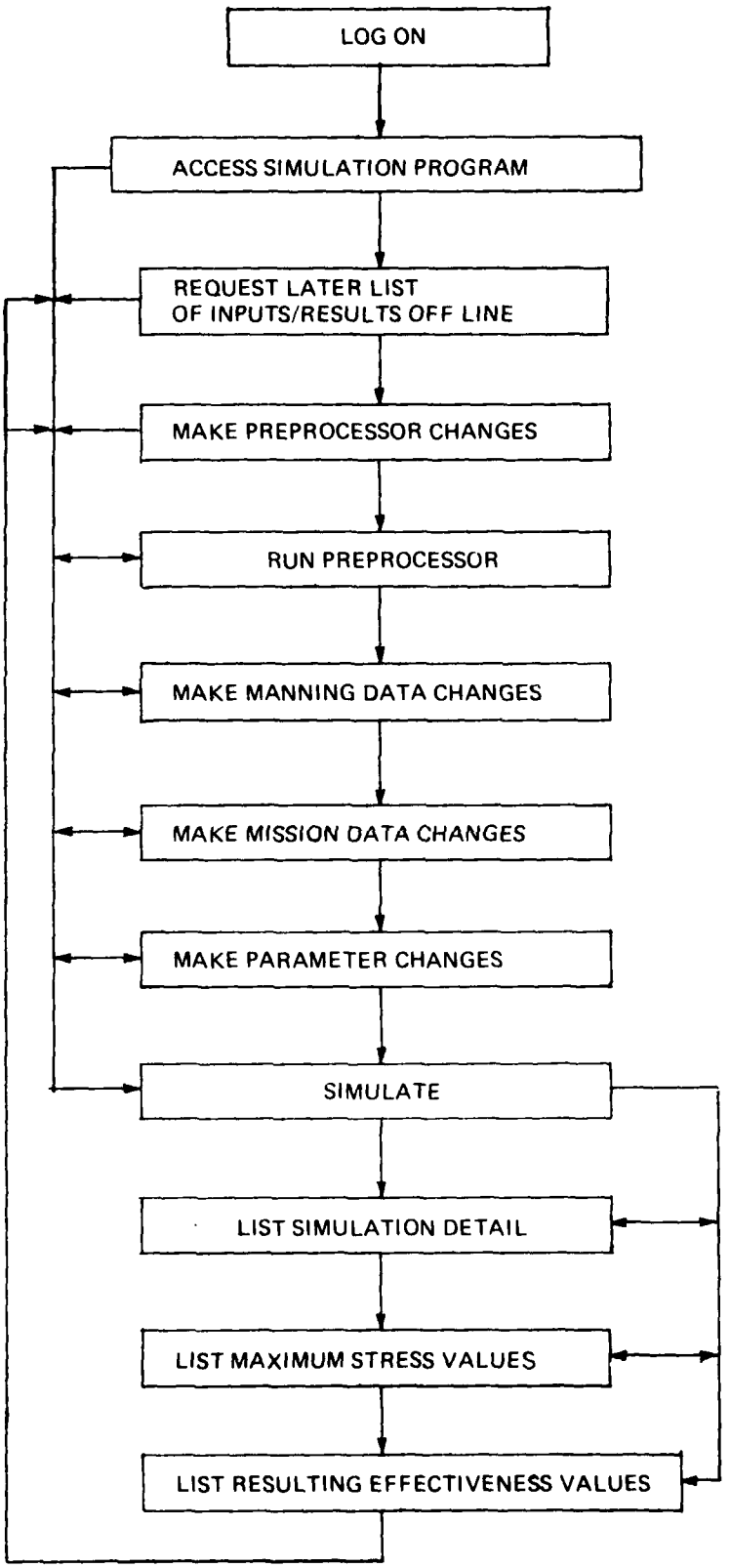


Figure 1.1. Global Model Flow

CHAPTER II

STEP-BY-STEP PLANNING INSTRUCTIONS

Because a battle scenario (mission), default values, and associated raw effectiveness values, and the like are already embedded in the PERFECT model, many of the steps described in Chapter II are customarily skipped during model use. This chapter lists and describes in a sequential manner all of the possible steps involved in planning to use the PERFECT model. The major elements included here are those involving familiarization, planning, and preparing data for the simulation:

- Selecting the strength (number of men) in each operational unit to be simulated
- Making any desired changes in the basic effectiveness table upon which calculations are based
- Developing a mission and preparing data
- Planning and selecting parameter values to be applied during the simulation.

The tasks involved in implementing the computer simulation are itemized in Chapter III.

All required mission, parameter and other data are already prestored and available. One or more computer runs may be made without developing a new mission or performing planning tasks. If the user does not wish to develop a new mission, but to utilize all data previously prepared, or if the user already has familiarity with the model, the user may continue directly with the procedures given in Chapter III.

Step A. Manning Table Development

1. Study the Manning Table Input form (Table 2.1).
2. Determine the number of men to be assigned in the simulation to each of the 16 duty positions. (It is also permissible to determine these values for a subset of the 16, i.e., only those combat types planned to be simulated).
3. If simulation runs are to be made using the number of men indicated in the Default Value column of Table 2.1, skip the rest of step A and go to step B below. In this case, it will not be necessary to perform any further manning

Table 2.1

Manning Table Input

Combat Unit Type Identifier (T)	Unit Type	Duty Position		No. of Men		No. of Critical Tasks
		Number DP	Name	Default Value	Number MEN(DP)	CT(DP)
1	Mechanized Infantry Squad	1	Gunner/Carrier Team Leader	1		17
		2	Maneuver Team Member	4		15
		3	Squad Leader	1		17
2	Mechanized Infantry Platoon Leadership	4	Platoon Leader	1		27
3	Tank Crew or Armor Crew	5	Tank Commander	1		15
		6	Tank Gunner	1		5
		7	Tank Loader	1		12
4	Tank Platoon Leadership	8	Tank Platoon Leader	1		26
5	Tank Crew Alternate	6	Tank Gunner	1		5
		7	Tank Loader	1		12
6	Fire Support Team (FIST)	9	Forward Observer	1		27
		10	Radio/Telephone Operator	1		1
7	Fire Support Team Leadership	11	FIST Chief	1		29
		12	FIST NCO	1		2
8	Artillery Section	13	Howitzer Section Chief	1		11
		14	155mm Gunner	1		17
		15	155mm Crew Member	3		14
9	Artillery Battery Leadership	16	Artillery Battery Executive Officer	1		6

table development as these values are prestored in the model. Also, in this case, it is not necessary to run the preprocessor program.

4. Otherwise, enter the number of men of each type into the blank column of Table 2.1. During the computer run, it will be necessary to enter these manning values and call for the preprocessor to be run.

Step B. Effectiveness Value Changes

A table of values is prestored within the model for end of day effectiveness for each combination of:

		Range	
Day	D	1 through 5	
Platoon Action	PA	1 through 3	(see Table 2.3)
Duty Positions	DP	1 through 16	(see Table 2.1)
Critical Tasks	CT	1 through 29	

Effectiveness values for all conditions are shown in Appendix D. The effectiveness matrix is a detailed list of projected effectiveness values for critical combat tasks as given in the Guidelines--Human Performance in Continuous Operations. The matrix consists of detailed effectiveness values by unit type and duty position for each critical task over a five day continuous operation.

The assumption is that all effectiveness values are equal to one (no degradation) at the start of the scenario. This is illustrated in Figure 2.1 for the mechanized infantry unit, maneuver team member, critical task 1, and platoon action 1. Data for a sixth mission day are calculated in the model's preprocessor by linear extrapolation. This extrapolation is required due to the technique selected for stress calculation.

1. If no changes are to be made to these values, proceed to step C below.
2. If changes are to be made, record the changes. These changes will be entered into the computer later by providing values of D, PA, DP, CT, and EFF for each change, where EFF is the end of day effectiveness (range 0 to 100).

If there are effectiveness value changes to be made, it will be necessary to run the proprocessor (once) to incorporate them into the simulation.

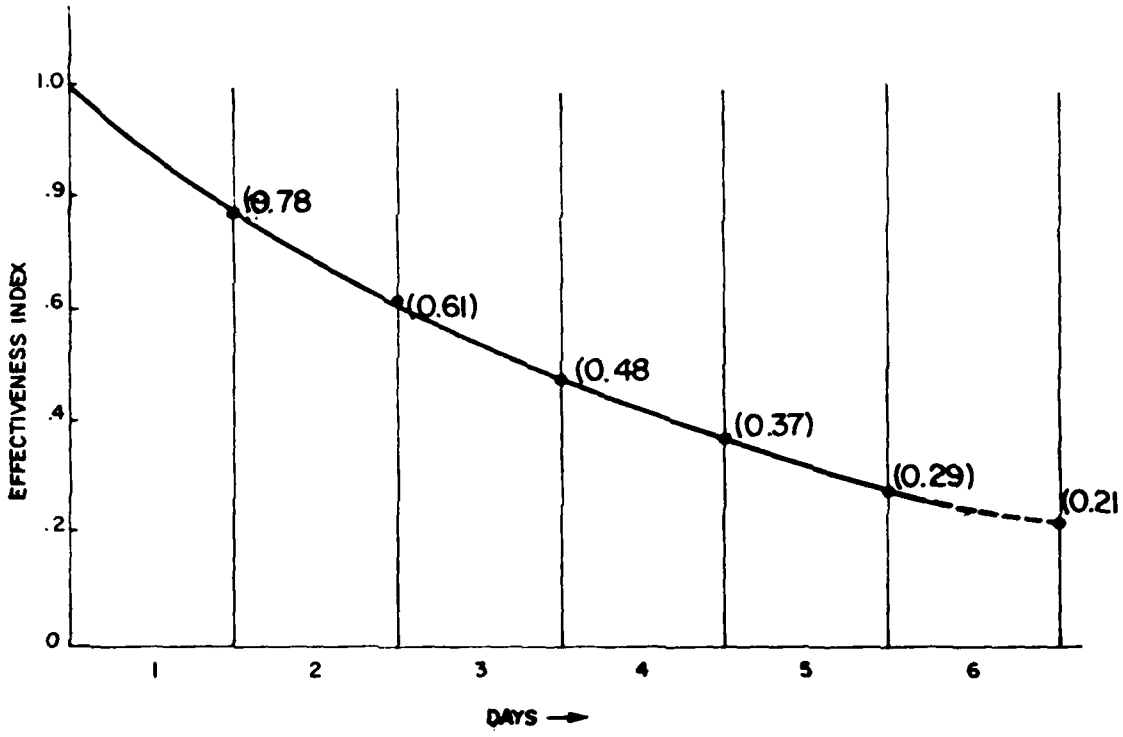


Figure 2.1: Example of "Effectiveness" curve (linear approximations are used in the model)

Step C. Mission Data Planning

1. Study the combat unit types listed in Table 2.1 and select the types to be simulated.
2. Select the number of each type of unit to be simulated. Refer to Table 2.2(a) for a sample.
3. Enter your selection of the number (i.e., quantity) of each type of combat unit on a copy of Table 2.2 (b). Do not enter a value of T greater than 9. Do not enter a value of U greater than 5.
4. Study the four platoon action code assignments: 0, 1, 2, and 3 presently implemented in the model. These are indicated by asterisks in Table 2.3.
5. Study the mission data table input requirements shown as an example in Table 2.4(a). Using the blank copy of that same format, shown in Table 2.4 (b) (or equivalent), design each desired mission one day (D) at a time, in order by T.

The mission data represent the sequential list of platoon actions and corresponding durations for each unit type to be simulated over the continuous operation. Up to five units of each of nine types can be specified in a run which simulates up to five days of continuous operation.

Note that:

a. For each combination of T and U values, the sequence number(s) begin with one.

b. Duration values are in hours and tenths of an hour. These values must range between 00.1 and 24.0

c. The sum of all duration values for a T, U pair must be 24.0 for each day, except possibly the last day for which the summary may be any value within the 00.1 to 24.0 range.

These data will be entered via the terminal in the order shown starting with the lowest T value.

Step D. Parameter Selection

1. Study the list of available parameters. Symbolic notation and the associated value ranges

Table 2.2

Combat Units to be Simulated

(a) Combat Unit Type Identifier (T)	(a) Example Number of Combat Units to be Simulated (U)	(b) Enter Data Here: Number of Combat Units to be Simulated (U)
1	2	
2	1	
3	2	
4	0	
5	1	
6	5	
7	0	
8	0	
9	1	

Table 2.3

Platoon Action Code Assignments

Platoon Action Number (PA)	Description	Platoon Action Type
0*	Sleep	Sleep
1*	Repel an enemy assault from a battle position	Active defense
2*	Create and defend a strong point	
3*	Disengage and occupy a new battle position	
4		
5	To be determined	Offensive operations
6		
7	Reconnaissance	Reconnaissance
8	Retrograde	Retrograde
9	To be determined	To be determined

*Currently implemented in model

Table 2.4

Mission Data

(a)						(b)					
DAY D	TYPE T	UNIT NO. U	SEQUENCE NO. S	PLATOON ACTION PA	DURATION DUR	D	T	U	S	PA	DUR
1	1	1	1	1	2.20						
1	1	1	2	2	4.30						
1	1	1	3	1	2.20						
1	1	1	4	3	8.30						
1	1	1	5	0	7.00						
1	1	2	1	1	24.00						
1	2	1	1	1	8.00						
1	2	1	2	2	8.00						
1	2	1	3	0	8.00						
1	3	2	1	1	24.00						
1	5	1	1	3	10.50						
1	5	1	2	1	3.00						
1	5	1	3	3	10.50						
1	6	1	1	0	8.00						
1	6	1	2	3	8.00						
1	6	1	3	2	8.00						
1	6	2	1	2	24.00						
1	6	3	1	3	24.00						
1	6	4	1	1	24.00						
1	6	5	1	0	24.00						
1	9	1	1	1	24.00						
2	1	1	1	1	12.00						
2	1	1	2	2	12.00						
2	1	2	1	1	24.00						
2	2	1	1	1	24.00						
2	3	2	1	1	24.00						
2	5	1	1	1	24.00						
2	6	1	1	1	24.00						
2	6	2	1	1	24.00						
2	6	3	1	1	24.00						
2	6	4	1	0	24.00						
2	6	5	1	1	24.00						
2	9	1	1	1	24.00						
3	1	1	1	2	4.00						
3	1	2	1	2	3.00						
3	2	1	1	2	2.00						
3	3	2	1	2	1.00						

are given in Table 2.5. The set of parameters was selected to make the model flexible, i.e., capable of simulating a wide range of interesting continuous operations situations, and so as to require no data collection or analysis by the user when he performs simulation runs.

2. Select a set of initial run parameters and enter them on a copy of Table 2.6, next to the sample data. Additional parameter sets may be selected either in advance or during terminal operations. Frequently, the results of one run will provide ideas for parameter selection for successive runs.

   a. Select UPF(T)=1 to represent a combat unit type of nominal proficiency. Greater proficiency values are specified by UPF(T) less than one; lower proficiencies represent UPF(T) greater than 1.

   b. Select one light level profile number (1-9) as input for each day of the simulated mission based on the light level (L) input data and conditions shown in Table 2.7. The light level profile input parameters identify one of the nine preselected 24 hour sets of light conditions shown in Table 2.8. Each value represents a type of day (weather) to be simulated. The individual values in Table 2.7 represent hourly light level conditions whose meanings are shown in Table 2.8.

   c. Select EFM, EFTA(D), and EFP values of unity to represent an equality between enemy and friendly forces in material, terrain advantage, and personnel respectively. Select values less than one to represent friendly forces advantage; greater than one represent enemy advantage.

   d. Use Table 2.9 to facilitate selecting the enemy/friendly terrain advantage input value. Three elements identified as significant in terrain advantage are: concealment, altitude advantage, and mobility. They are assumed to have equal

Table 2.5

Parameters

No.	Parameters	Program Name	T Format	Permissible Range
1	Unit proficiency factor, proficiency of troops in each unit	UPF(T)	X.X	0.6-1.5
2	Enemy/friendly material strength ratio	EFM	XX.X	0.1-10.0
3	Enemy/friendly terrain advantage ratio for each day	EFTA(D)	X.X	0.2-5.0
4	Enemy/friendly personnel strength ratio	EFP	XX.X	0.1-10.0
5	Light level profile for each day	L(D)	X	1-9
6	Time of day battle starts, an hour number	HR	XX	0-23
7	Unit replacement data, i.e., conditions for replacement for each of up to 20 replacements, R			
	Combat unit type (enter in time sequenced order)	RT(R)	X	1-9
	Combat unit number (enter in time sequenced order)	RU(R)	X	1-9
	Day number of battle (enter in time sequenced order)	RD(R)	X	1-5
	Time of day (enter in time sequenced order)	RH(R)	XX	1-23
8	Hours since last sleep at start of battle	HSLS	XX	0-99

Table 2.6

Parameter Values

		Unit Proficiency Factor		
	T	Sample Data	Enter Selected Parameters Here	Permissible Range
UPF(T)	1	1.2		0.6-1.5
	2	1.0		
	3	1.0		
	4	.0		
	5	1.0		
	6	1.0		
	7	.0		
	8	.0		
	9	1.0		
EFM	EFM	1		0.1-10.0
EFP	EFP	0.8		0.1-10.0
EFTA(D)	D	-		-
	1	1.2		0.2-5.0
	2	1.1		
	3	1.0		
	4	-		
	5	-		
L(D)	D	L(D) Sample		-
	1	2		1-9
	2	1		
	3	3		
	4	-		
	5	-		
HR	HR	4		0-23
Replacement Data	S	D T U HR		-
	1	2 2 1 4		
	2			D=1-5
	3			T=1-9
	4			U=1-5
	5			HR=1-23
	6			
	.			
	.			
	.			
	20			
HSLS	HSLS	16		0-99

Table 2.7

Light Level Information

L= Light Level Profile Number	Season	Type of Day	H=	Value of Light Level at Each Hour-LIGHT (L,H)																							
				* 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	Winter	Hazy, overcast, no moon		1	1	1	1	1	3	5	7	7	7	7	7	7	7	7	7	5	3	1	1	1	1	1	1
2	Winter	Clear, no snow, full moon		3	3	3	3	3	4	6	9	9	9	9	9	9	9	9	9	6	4	3	3	3	3	3	3
3	Winter	Clear, snow, no moon		2	2	2	2	2	3	6	9	9	9	9	9	9	9	9	9	6	3	2	2	2	2	2	2
4	Winter	Clear, snow, full moon		4	4	4	4	4	5	7	9	9	9	9	9	9	9	9	9	7	5	4	4	4	4	4	4
5	Spring/ Fall	Clear, hazy, half moon		2	2	2	2	2	3	5	7	8	8	8	8	8	8	8	8	8	6	4	3	2	2	2	2
6	Spring/ Fall	Clear, half moon		2	2	2	2	3	4	6	8	9	9	9	9	9	9	9	9	9	8	6	4	3	2	2	2
7	Spring/ Fall	Rain, overcast, no moon		1	1	1	1	2	4	6	7	7	7	7	7	7	7	7	7	7	6	4	2	1	1	1	1
8	Summer	Fair, half moon		2	2	2	3	5	9	9	9	9	9	9	9	9	9	9	9	9	9	6	5	2	2	2	2
9	Summer	Rain, overcast, no moon		1	1	1	2	4	7	7	7	7	7	7	7	7	7	7	7	7	7	5	2	1	1	1	1

* Represents clock time of 0100 (i.e., 1:00 AM)

Table 2.8

Light Level Categories

LIGHT (L,H) Value of Light Level	Light Conditions
1	Starlight on earth
2	Starlight on snow or half moon
3	Full moon on earth
4	Full moon on snow
5	Late twilight
6	Early twilight/dense clouds or haze
7	Overcast day/light haze
8	Light, overcast day
9	Clear, sunny day

Table 2.9

Terrain Advantage Parameter Selection Guide

Enemy/Friendly Terrain Advantage Parameter Value (EFTA)	Number of Elements		
	Enemy Advantage	Equal	Friendly Advantage
0.2	All 3	-	-
0.4	Any 2	1	-
0.6	Any 2	-	1
0.8	Any 1	2	-
1.0	-	All 3	-
1.0	Any 1	Any 1	Any 1
1.25	-	Any 2	Any 1
1.67	Any 1	-	Any 2
2.5	-	Any 1	Any 2
5.0	-	-	All 3

importance. Table 2.9 shows various conditions of enemy, friendly, or no advantage and a corresponding value of the input parameter which can be selected to represent each of the cases. The range was selected so that there is a five to one swing from the equilibrium condition to the case in which either side has complete advantage.

e. Select HR as the time of day when the battle is to begin where 00.0 is midnight and 12.0 is noon.

f. Select up to 20 sets of replacement data to define the conditions of platooning desired.

g. Select HSLS to represent the number of hours since the friendly forces slept last.

Step E. Factor Identification

1. Become familiar with the meaning of the five assigned factors (Table 2.10). Each critical task for which effectiveness data are prepared has been categorized into one of the factors. The original factor derivation was based on a factor analysis of the various tasks. This factor analysis is described in Appendix II to Siegel, et al., 1980. Appendix E of this user's manual shows a complete listing of the current factor assignments for each duty position and critical task. Output results are given both by day and by factor.

Table 2.10

Factors and Factor Task Assignment Values

Factor Number (F)	Factor
1	Command and Control
2	Combat Activity
3	Coordination and Information Processing
4	Preservation of Forces and Regrouping Activity
5	Orientation to Friendly and Enemy Troops

CHAPTER III

STEP BY STEP MODEL USER'S INSTRUCTIONS

Chapter III describes the sequential steps which form the basis for use of the PERFECT model. Generally, each simulation (processing) run requires a very similar set of user operations. It is expected that familiarity with the procedures will be gained after only a very few usages, i.e., a significant facility both in the use of the model and the computer terminal does not require a knowledge of computers or programming.

The user operations itemized in this chapter may be performed at a computer terminal which can be either a cathode ray tube type device with keyboard or a hard copy printer-terminal. The type of terminal and line speed are essentially independent of the program, although the program was developed for use with a teletype KSR.

Accordingly, the term "print" used in this chapter also means "display" for a CRT terminal. The primary instructions, presented in this chapter, are summarized in symbolic or logical form in Appendix A. The terminal user may utilize either the text which follows or the Appendix A diagram as a source for guidance. Initially, the following step-by-step guidance will be helpful because it provides some background information or reasoning on the procedures. Later, after practice has yielded facility, the user may find that a written procedure is not necessary and use Appendix A for guidance. Still later only infrequent reference to the materials may be required. If necessary to the model application run under consideration, it is assumed that the planning tasks described in Chapter I have been completed.

Step F. Terminal Log-on

1. Dial the phone number of the computer center (for remote operation).
2. Turn the modem or coupler "ON" (if it is a device separate from the terminal).
3. Upon hearing a high pitched sound in the phone's receiver, place the phone's handset into the modem (coupler). Be sure the mouthpiece is placed in the cord end receptacle.
4. Turn the terminal's mode switch to the "LINE" ("REMOTE") position to indicate that interactive (not local) operations are to follow.

5. Press the RETURN key. On some terminals, this key is marked TRANSMIT, or some other similar name.

6. Press and hold simultaneously the "CONTROL" and "SHIFT" keys. While these are pressed, also press the "M" key. Then enter your user identification code and charge number obtained from the computer center. The computer will respond with:

   CONNECT CODE=XXXX
   XXX BLOCKS FILE SPACE AVAILABLE
   ETC, and end with an asterisk:
   "*"

Step G. Other Terminal Operations

This section describes some utility operations which a terminal operator may need before, during, and after simulation model runs. Each is independent of the other and these procedures may be performed in any order.

If the operator is already familiar with these operations (or their availability) and is ready to begin model simulation model runs, proceed directly to step H below:

1. To terminate terminal operations: (this procedure can be used only following the printing of an * (see G. 3 below)).

   a. Enter BYE and press the RETURN key.

   b. Computer will print the cost of this terminal session and the total cost on this charge to date, followed by log-on time, log-off time, and date.

2. To correct operator typing errors:

   a. To delete a line entered prior to its transmission to the computer; hold down the "CONTROL" key and simultaneously press the "X" key.

   b. To delete the most recent character (TTY only) entered prior to its transmission, hold down the "CONTROL" key and simultaneously press the "H" key.

3. To terminate a terminal print before its completion or to signal completion of all runs desired for a single session:

   a. Press the "BREAK" key:

   b. The computer will respond by stopping the transmission of data which are being processed and will cause a carriage return followed by "*."

4. To list the basic files stored as part of the model (input tables) program:

   a. Obtain the computer "*" output (see G. 3 above).

   b. Select the desired file (shown below) and and enter (as shown below): press the RETURN key:

File	Enter
Effectiveness = E1	LIST EFF1
Factors	LIST FACTOR1
Manning	LIST MEN
Mission	LIST MISSION
Selected program subroutine	LIST [Subroutine name]

Step H. Simulation Run Setup and Preprocessor

Specific terminal operations and computer responses are shown in logical/graphical form in Appendix A. Use of the Appendix A materials will facilitate terminal operation.

SET UP

The following procedures are initiated following step F. 6 above:

1. Enter OLD PERFECT and press the RETURN key.
2. The computer will print: *
3. Enter FRN and press the RETURN key. (FRN signifies a FORTRAN language run.)
4. The computer will print the date and time. It will querie whether or not output data and intermediate arrays are to be printed at the

computer center off-line via line printer. These arrays include preprocessor matrices, all input values including the effectiveness table, matrices from the simulation run, and the maximum stress table.

5. Respond by pressing Y or N and the RETURN key. Here and hereafter, Y signifies "YES" and N is "No."

PREPROCESSER

6. The computer will ask whether or not the preprocessor is to be run prior to the next simulation. It is only necessary to run the preprocessor to incorporate new data representing any one or more of the following:

   a. Changes to the manning data (see Table 2.1).

   b. Changes/corrections to the initial input matrix of effectiveness values. (Appendix D)

   c. Changes to assignments in the factor table (Appendix E).

   Otherwise, the model retains the results of the preprocessor run using the most recent data for effectiveness, manning, and factor values.

7. Respond by pressing Y or N and the RETURN key.

8. If preprocessing is not selected, go to step J (there is no step I).

EFFECTIVENESS CHANGES

9. If running the preprocessor is selected, the computer will solicit new values of effectiveness and print the allowable range of the four categories (see step B above).

10. Enter values for day number, platoon action, duty position, critical task number, and the new effectiveness value sequentially, separated by commas without spaces, and press the RETURN key. After the last such entry is made, enter 0,0,0,0,0 and press the RETURN key.

11. If not, respond N and press the RETURN key.

FACTOR CHANGES

12. The computer queries whether changes in the factor table (Appendix E) are desired (see step E above). If no such changes are to be made: respond N, press the RETURN key, and proceed to step H. 14 below.

13. If Y, follow the computer presented instructions on value ranges entering the duty position, critical task, and new factor value separated by commas (without spaces) and press the RETURN key.

    Do this for all factor changes. When no furthur changes of factors are desired: enter 0, 0, 0, and press the RETURN key.

MANNING CHANGES

14. The computer queries whether manning changes are desired.

15. If none are desired: respond N, press the RETURN key and go to step J. 1 below.

16. If changes are desired: enter a duty position number, comma, number of men desired for that duty position, and press the RETURN key.

    When no further manning changes are desired: enter 0, 0 and press the RETURN key.

17. The computer now runs the preprocessor (see Appendix B).

Step J. Simulation Run Inputs

LIST MISSION

1. The computer queries the operator's interest in having a current list of mission data printed at the terminal.

2. If the list is not desired: enter N, press the RETURN key, and go to step J. 4 below.

3. If the list is desired: enter Y, press the RETURN key, and the entire current set of mission data will be listed. Table 2. 4 shows a sample of this table.

MISSION CHANGES

4. The computer queries the operator's interest in making changes to the mission data. (See step C above)

5. If no changes are desired: enter N, press the RETURN key, and go to step J.7 below.

6. If mission changes are desired; follow the computer instructions which are printed at the terminal, entering, day number, combat unit type, combat unit number, sequence number, platoon action number, duration, and change type.

   When no further mission data changes are desired: enter 0, 0, 0, 0, 0, 0, 0, and press the RETURN key.

7. The computer will then print a table containing:

   a. All combat unit type (T) and combat unit number (U) pairs to be simulated.

   b. The number of days in the mission. A sample appears below:

```
T  U  USED
1  1
1  2
2  1
3  2
5  1
6  1
6  2
6  3
6  4
6  5
9  1

#DAY = 3
```

8. The computer then reports:

   MISSION DATA WRITTEN TO OUTPUT FILE

PARAMETERS

9. The computer queries whether the parameters to be used in the next simulation run should be read from the file (i.e., the previous set of

parameters, possibly to be changed now) or whether so many of them are to be changed that it would be preferable to enter new values for all of them now. (see step D above, and particularly Tables 2.5 and 2.6.)

10. If it is decided to read the prior set of parameters: enter N, press the RETURN key, and go to step J.12 below. The parameters will then be read from file.

11. If it is preferable to enter all of the new parameters: enter Y, and press the RETURN key. (see Appendix A circle G) In this case the computer will provide a prompted scenario in which a value is selected for each applicable parameter in the order shown in Table 2.b. Data will be requested only for those unit types and days to be simulated. For each parameter, select a value (the value must be within the allowable range printed by the computer), enter it upon request, and press the RETURN key. This process ends with the entry of a value for hours since last slept (HSLS).

12. The computer now provides the opportunity to list all parameter values by querying whether or not the operator wants this list.

13. If the list is not desired: enter N, press the RETURN key and go to step J.15.

14. If it is desired to have the parameter list printed: press Y, and the RETURN key. The computer will then list all parameters in the format:

INPUT PARAMETERS

TYPE	UNIT PROF FACTOR	
1	1.2	only those unit types to be simulated
2	1.1	
3	1.1	
5	1.1	
6	1.1	
9	1.1	
EFM	1.3	
EFP	Ø.8	

```
DAY   TERR
      ADV
1     1.2
2     1.2
3     1.2
DAY   LIGHT
  1     1
  2     2
  3     3
HR      1
REPLACEMENTDATA
 #   DAY  TYPE  UNIT  HR
 1     2     2     1   4
HSLS   24
```

15. The computer then queries as to whether individual parameters are to be modified.

16. If no: press N, the RETURN key, and proceed to step J. 18.

17. If yes: enter Y, press the RETURN key, and the computer will list the eight parameter types for your selection:

    UPF - Unit Proficiency Factor
    EFM - Enemy/Friendly Material strength ratio
    EFP - Enemy/Friendly Personnel strength ratio
    EFTA - Enemy/Friendly Terrain Advantage
    L - Light level
    HR - Hour mission begins
    REP - Replacement
    HSLS - Hours Since Last Sleep.

18. The computer requests the entry of a selected INPUT TYPE.

19. Select the type desired, enter one of the abbreviations listed above, and press the RETURN key. The computer will provide prompting on the data required and ranges of values to be entered.

20. Select the value within the range shown, enter it, and press the RETURN key. Decimal points and decimal values are acceptable for some parameters.

21. Repeat steps J.18 through J.20 for each parameter to be entered. To signal completion of all parameter changes, enter END as an input type, press the RETURN key, and continue with step K.

Step K. Simulation Run Execution

In preparation for the simulation calculation, the operator is asked to indicate the level of output detail desired:

OUTPUT OPERATIONS

1. The computer queries whether a detailed printout of the values of primary simulation variables is desired. A sample of such output, provided for each and every platoon action simulated is shown below:

```
L(D)= 1 H = 9 LIGHTF =  1.40
VUL  0.28  0.18   0.34  0.13  0.05
STRESS =    0.40     0.25    0.47   0.19  0.07
STRESS =    0.30
HRI1=  0.05 HRI2=  0.07
D=1 T=1 U=1 PA=1 DUR=2.20 CTIME = 8.70
STIME =  8.77
SD=  1
SLPDEP = 8.70
ECUR=0.9271  0.9527  0.9002  0.9675  0.9878
E4= 0.0074  0.0052  0.0147  0.0027  0.0010
```

   This level of detail will usually not be useful to most model users.

2. If not desired: enter N, press the RETURN key, and continue with step K.4.

3. If detail is required: respond by pressing Y and the RETURN key.

4. The computer queries whether the on-line listing of maximum stress values is desired. The format for this is:

MAX STRESS ARRAY

DAY	MAXST	MAXTM	T	U
1	8.98	17.00	1	1
2	23.04	24.00	1	1
3	27.13	4.00	1	1
2	4.63	24.00	1	2
3	18.70	3.00	1	2
1	1.88	16.00	2	1
2	1.10	24.00	2	1
3	3.75	2.00	2	1
2	2.23	24.00	3	2
3	7.24	8.00	3	2
1	1.51	24.00	5	1
1	11.94	24.00	6	1
2	4.45	24.00	6	1
2	3.07	24.00	6	2
2	4.33	24.00	6	3
2	1.14	24.00	9	1

One maximum value is printed for each combat unit on each day. The meaning and calculation of stress is discussed in Appendix B.

5. If the list is not desired: press N and the RETURN key. If so: press Y and the RETURN key.

SIMULATE

6. The computer will then execute the calculations involved in the simulation model using current values for all platoon actions in the mission data, the factors, effectiveness values, and parameters over all days starting at the beginning of day 1. See Appendix B for a description of calculations.

OUTPUTS

7. If previously requested in step K. 3 above, the detailed printout will be listed on the terminal by the computer.

8. If previously requested in step K. 5 above, the maximum stress value table will be printed.

9. The computer will unconditionally print the major model results in the form of two tables of effectiveness values. A sample of these tables is shown in Table 3. 1. The first part shows end-of-day effectiveness values by factor and the second shows end-of-day effectiveness values by type of combat unit for each mission day.

10. Following this output, the computer returns to step H. 14 above to query about the desirability of entering manning changes for next simulation run. This corresponds to circle H on the Appendix A flowchart, and represents the beginning of the cycle of interactions for the next computer run. If another run is desired, return to step H. 14 and continue.

11. Otherwise, press BREAK (see step G. 3) and enter the log off process (see step G. 1). The same log off can be achieved if the next three questions are answered NO (Manning changes, Mission changes, and Parameter read changes.)

12. After a terminal session (each run), the user can request a printout of the intermediate arrays including preprocessing.

    a. After *, enter BPRINT NOSEDATA

    b. Computer will respond IDENT

    c. Enter: ZEDD61, VFIAMS, 088457, 5631

    d. Arrange for pick up from the computer center of any intermediate tabulations requested during the runs.

13. Alternately, these intermediate results may be noted on the terminal. Enter:

    L NOSEDATA and press RETURN.

Table 3.1

Final Output--Example

Effectiveness by Day and Factor (E7)

Factor

Day	1	2	3	4	5	Avg
1	0.81	0.88	0.74	0.67	0.58	0.74
2	0.67	0.79	0.67	0.55	0.50	0.64
3	0.60	0.74	0.63	0.48	0.46	0.58
4	0.55	0.69	0.60	0.43	0.43	0.54
5	0.50	0.66	0.57	0.38	0.41	0.50

Effectiveness by Day and Type (E8)

Combat Unit Type

Day	1	2	3	4	5	6	7	8	9	Avg
1	0.78	0.64	0.92	0.	0.92	0.77	0.	0.	0.39	0.74
2	0.65	0.57	0.80	0.	0.89	0.53	0.	0.	0.37	0.64
3	0.58	0.52	0.75	0.	0.86	0.42	0.	0.	0.36	0.58
4	0.53	0.48	0.70	0.	0.84	0.34	0.	0.	0.36	0.54
5	0.49	0.44	0.67	0.	0.81	0.27	0.	0.	0.35	0.50

CHAPTER IV

INTERPRETING MODEL OUTPUT

To perform effectiveness evaluations using the PERFECT model, the user enters systematically sets of rationally selected parameters and the model processes the input data according to its internal algorithms to yield projected effectiveness values. The parameter values which are entered into the model are of a fixed form in which the numerical values (magnitudes) of certain characteristics of the situation of interest are stated. This set of numerical values is called the "input parameters," and is discussed in Chapter II. Obviously, the numerical value for each input parameter can be set "high," "low," or "moderate." In addition, the combinations (permutations) of values across the set of parameters permits a very large number of variations to be investigated. For example, a friendly/enemy force ratio may be systematically varied while unit proficiency values, terrain advantage, platooning, etc. are held constant or various combinations of parameters may be varied.

The model's mathematical algorithms amount to a set of rules by which each of the input parameters and combinations of the parameters are examined and evaluated. Then, by a further set of rules, an outcome is projected. This outcome (or output) is stated as a set of numerical values.

Interpretation of Effectiveness (E) Values

The PERFECT model projects the effectiveness of the units simulated along a 0.00 to 1.00 scale. It does not predict whether the friendly or the enemy forces will be victors in the given engagement; it does not predict casualties, equipment losses, locations, or similar matters that are projected by conventional battle models. The human performance effectiveness (E) output scale ranges from 0.00 to 1.00. While a decimal point appears in the index because of internal calculational necessity, the decimal point may be ignored in output interpretation. Accordingly, the E value can be viewed as a percentage of effectiveness. The effectiveness (E) of a unit prior to combat amounts to 100 percent, and the effectiveness of this same unit when exhausted by prolonged battle under exceedingly adverse conditions may decline to zero. In this case, the unit has lost further tactical, military usefulness, even though it might miraculously have sustained no casualties or equipment losses. The unit's personnel is too exhausted to perform its combat tasks properly. Effectiveness (E) values are projected by combat unit type over five days (120 hours) of battle as well as for "factors" over these five days. "Factors" refers to major dimensions or types of combat activity such as, command and control activity, coordination and information processing, and so forth (see Table 2.10).

Parameter Variation

Whenever PERFECT is exercised, a specified set of input parameters (numerical descriptions) is examined, evaluated, and effectiveness projections (E values) are produced. Theoretically, virtually any imaginable tactical situation can be described and effectiveness projections obtained. In most uses, parameters will be varied and the prestored battle scenario will be employed. This means that, for example, outcomes of otherwise identical battle engagements can be compared for effects of "high" versus "low" unit proficiency, terrain advantage, personnel ratio, and so forth. In this mode of use, interest is focused primarily on differences in obtained outcome values (of E), or in comparative patterns of outcomes rather than in specific magnitudes of E ("percentage" of effectiveness).

Obtaining a Baseline

In exercising the PERFECT model for purposes of comparing patterns of outcomes, it is desirable to establish a baseline representing, perhaps, the most likely conditions. The selected baseline depends, in each case, on the user's interests and purposes. However, the process can be illustrated.

During the development of PERFECT, a hypothetical five day test mission was developed in which the value for each input parameter was set at unity (1.00). Further, no allowances were made for sleep and replacements in the units in question. These input parameters (descriptions) are shown below in Table 4.1. Note that the description (input parameters) in Table 4.1 was composed for illustrative purposes and has no military meaningfulness. It is an arbitrary description serving only as a test exercise.

The outcome of the sample baseline simulation with input parameters all set to unity (1.00) is shown in Table 4.2. Table 4.2 is divided into two parts. Each part reflects one of the outcomes provided by PERFECT. Table 4.2(a) presents projected effectiveness in five major categories of combat activity, and Table 4.2 (b) presents the effectiveness for each specified type of unit. Since types 4, 7, and 8 were not specified among the input parameters, and accordingly not included in the simulation, zero effectiveness is shown for them on each day. Characteristically, in these outcomes, the greatest effectiveness decrement tends to occur on the early simulated days (down the columns) and incremental degradation diminishes later. Note that in Table 4.2 an average effectiveness for each day (across the columns) is given--across "factors" and across "combat unit types."

Table 4.1

Sample Specification of Baseline Input

Input Parameters		Interpretations
Type	Unit Prof Factor	
1	1.0	Mechanized infantry squad
2	1.0	Mechanized infantry platoon leadership
3	1.0	Tank crew
5	1.0	Alternate tank crew (2 man)
6	1.0	Forward observer/RTO team
9	1.0	Artillery battery executive officer
EFM	1.0	Enemy/friendly material strength ratio
EFP	1.0	Enemy/friendly personnel strength ratio
Day	Terr. Adv.	
1	1.0	Enemy/friendly terrain advantage
2	1.0	
3	1.0	for
4	1.0	
5	1.0	each day
Day	Light	
1	1	Light level profile
2	1	
3	1	for
4	1	
5	1	each day
HR	1	Hour of day when battle starts
HSLS	0	Hours since last sleep at battle start

Table 4.2

Outcome of Arbitrary (Baseline) Test Exercise

a. Effectiveness (E) per Day for 5 Types of Combat Activity (Factors)

	Factor					
Day	1	2	3	4	5	Avg
1	0.86	0.92	0.76	0.72	0.59	0.77
2	0.76	0.86	0.70	0.64	0.54	0.70
3	0.68	0.81	0.66	0.56	0.50	0.64
4	0.62	0.76	0.63	0.50	0.47	0.59
5	0.53	0.72	0.60	0.45	0.44	0.55

b. Effectiveness (E) per Day and Unit Type

	Combat Unit Type									
Day	1	2	3	4	5	6	7	8	9	Avg
1	0.84	0.72	0.92	0.	0.96	0.80	0.	0.	0.39	0.77
2	0.74	0.66	0.85	0.	0.93	0.64	0.	0.	0.38	0.70
3	0.66	0.60	0.80	0.	0.90	0.52	0.	0.	0.37	0.64
4	0.61	0.55	0.75	0.	0.87	0.41	0.	0.	0.36	0.59
5	0.57	0.51	0.71	0.	0.85	0.29	0.	0.	0.35	0.55

Obtaining a Best and Worst Case

A baseline outcome is one obtained when "average" expected conditions (input parameters) are specified. Then, the effects of deviations in one or more conditions on projected baseline outcomes can be examined. In some cases, however, it may be advantageous to stipulate the limits on the conditions under which the mission in question may have to be carried out. The upper limit amounts to the best conditions, and the lower limit amounts to the worst conditions. Comparing outcomes under best and worst conditions establishes the envelope for intermediate possibilities.

If the envelope is very narrow, performing runs with intermediate input parameter values may not be warranted. On the other hand, the envelope may be wide. In this latter case, it is of interest to establish the intermediate conditions or whether any changes (combinations of input parameters) produce an outcome approximating that obtained under the best conditions. Similarly, the reverse (approximation of worst conditions) can be established to reveal the most "vulnerable" factors in the situation.

Table 4.3 shows the inputs to a simulation for a hypothetical "best" case. On the left side of the table, the types of military units and the number of each type (see Table 2.2) participating are listed. The right side lists the input parameters used for this "best" case simulation. The unit proficiency input parameters represent military units which are superbly trained. The enemy has a 3:1 superiority in weapons (EFM) and personnel (EFP). Terrain advantage shifts over the five days, but is "fair" overall. Lastly, the engagement starts at 1000 hours, and only four hours have elapsed since troops slept last. These conditions are in plausible alignment with the scenario in Siegel, et a., (1980).

Table 4.4 shows the outcome obtained with the input parameters specified in Table 4.3. The interpretation of Table 4.4 is parallel to Table 4.2.

The "worst" case for the same hypothetical mission is now specifed by making changes in the input parameters as shown in Table 4.5. These parameters specify the worst conditions that might be considered for the hypothetical mission. Since Table 4.5 represents the same mission as Table 4.3, types and number of participating military units are the same and are omitted in Table 4.5. Some differences are worth noting.

First, the participating military units are very poorly trained. Second, the enemy has a 6:1 (rather than 3:1) superiority in weapons and personnel (EFM, EFP). Third, terrain advantage overall tends to be "poor" rather than "fair." Fourth, the battle begins at 1600 hours, and it has been eight hours since troops slept last. On the positive side; three tank crews have been replaced on the first day of battle.

Table 4.6 shows the outcome obtained with the input parameters specified in Table 4.5.

Table 4.3

Hypothetical Mission: Best Conditions

Input Parameters				Interpretations
T	U Used	Type	Unit Prof Factor	
1	1	1	0.6	Mechanized infantry squad
1	2	2	0.6	Mechanized infantry platoon leadership
1	3	3	0.6	Tank crew
2	1	4	0.6	Tank platoon leadership
3	1	6	0.6	Forward observer/RTO Team
3	2	7	0.6	FIST leadership
3	3	8	0.6	Howitzer crew
3	4	9	0.6	Artillery battery leadership
4	1			
6	1	EFM	3.0	Enemy/friendly material strength ratio
6	2			
6	3	EFP	3.0	Enemy/friendly personnel strength ratio
7	1			
8	1	Day	Terr.	
8	2	Day	Adv.	
8	3			
8	4	1	5.0	Enemy/friendly terrain advantage
9	1	2	2.5	
		3	0.4	for
# Day = 5		4	0.2	
		5	1.7	each day
		Day	Light	
		1	1	Light level profile
		2	3	
		3	1	for
		4	4	
		5	4	each day
		HR	10	Hour of day when battle starts
		HSLS	4	Hour since last sleep at battle start

Table 4.4

Hypothetical Mission: Outcome Under Best Conditions

Effectiveness by Day and Factor (E7)

	Factor					
Day	1	2	3	4	5	Avg
1	0.69	0.86	0.79	0.72	0.61	0.74
2	0.56	0.78	0.76	0.63	0.55	0.66
3	0.54	0.77	0.75	0.62	0.54	0.64
4	0.52	0.75	0.73	0.59	0.51	0.62
5	0.42	0.69	0.68	0.53	0.46	0.56

Effectiveness by Day and Type (E8)

	Combat Unit Type									
Day	1	2	3	4	5	6	7	8	9	Avg
1	0.79	0.61	0.96	0.87	0.	0.69	0.77	0.88	0.31	0.74
2	0.69	0.53	0.94	0.82	0.	0.54	0.67	0.79	0.27	0.66
3	0.68	0.51	0.93	0.80	0.	0.53	0.65	0.78	0.27	0.64
4	0.66	0.50	0.90	0.76	0.	0.50	0.63	0.77	0.26	0.62
5	0.60	0.44	0.88	0.70	0.	0.37	0.53	0.71	0.24	0.56

Table 4.5

Hypothetical Mission: Worst Conditions

Input Parameters		Interpretations
Type	Unit Prof Factor	
1	1.5	Mechanized infantry squad
2	1.5	Mechanized infantry platoon leadership
3	1.5	Tank crew
4	1.5	Tank platoon leadership
6	1.5	Forward observer/RTO team
7	1.5	FIST leadership
8	1.5	Howitzer crew
9	1.5	Artillery Battery leadership
EFM	6.0	Enemy/friendly material strength ratio
EFP	6.0	Enemy/friendly personnel strength ratio
Day	Terr. Adv.	
1	5.0	Enemy/friendly terrain advantage
2	1.7	
3	1.0	for
4	0.6	
5	0.2	each day
Day	Light	
1	1	Light level profile
2	1	
3	1	for
4	1	
5	1	each day
HR	16	Hour of day when battle starts

Replacement Data

#	Day	Type	Unit	HR
1	1	3	3	10

HSLS	8	Hour since last sleep at battle start

Table 4.6

Hypothetical Mission: Outcome Under Worst Conditions

Effectiveness by Day and Factor (E7)

	Factor					
Day	1	2	3	4	5	6
1	0.37	0.69	0.67	0.53	0.43	0.54
2	0.14	0.27	0.42	0.19	0.21	0.24
3	0.12	0.20	0.33	0.12	0.16	0.19
4	0.12	0.18	0.28	0.09	0.15	0.16
5	0.11	0.17	0.24	0.08	0.14	0.15

Effectiveness by Day and Type (E8)

	Combat Unit Type									
Day	1	2	3	4	5	6	7	8	9	Avg
1	0.55	0.34	0.91	0.68	0.	0.30	0.52	0.76	0.24	0.54
2	0.14	0.11	0.87	0.40	0.	0.02	0.10	0.30	0.01	0.24
3	0.12	0.08	0.83	0.26	0.	0.	0.02	0.19	0.	0.19
4	0.11	0.06	0.78	0.15	0.	0.	0.	0.18	0.	0.16
5	0.10	0.03	0.75	0.12	0.	0.	0.	0.18	0.	0.15

Best Versus Worst Case Comparisons

Summary comparison can be made by contrasting the End-of-Day averages, which are found at the extreme right in each table. Table 4.7 contrasts the End-of-Day averages of Tables 4.4 and 4.6.

Table 4.7

Best/Worst End-of-Day Effectiveness

Day	Best	Worst
1	.74	.54
2	.66	.24
3	.64	.19
4	.62	.16
5	.56	.15

Even the direct comparison of corresponding numerical values, however, will be less well and less quickly appreciated than a graphic comparison. That is, each set of values of interest (e.g., those in Table 4.7) can be plotted so as to produce an equivalent graph as shown in Figure 4.1.

It will be evident from Figure 4.1 that differences are more readily apparent in the graphic form, and this is particularly true for comparisons of overall trends. At times, it may be useful to plot outcomes of intermediate conditions within the envelope of the best and worst expected conditions (upper and lower limits) so that all potential outcomes may be compared simultaneously.

Sensitive, analytic use of PERFECT should not confine itself merely to overall comparisons. PERFECT lends itself to analytic comparisons of component details in the overall performance degradation process. For example, a Maximum Stress Array may be obtained on-line. Table 4.8 shows selected comparisons of maximum stress values for corresponding types of military units under best and worst conditions. These stress values are taken from the same hypothetical mission which constitutes the background for Tables 4.3 through 4.6. Table 4.8 indicates vastly different levels of maximum stress (MAXST) to be experienced under best and worst conditions. Also, the time of day (MAXTM) at which the maximum stress occurs tends to be considerably earlier for the worst conditions.

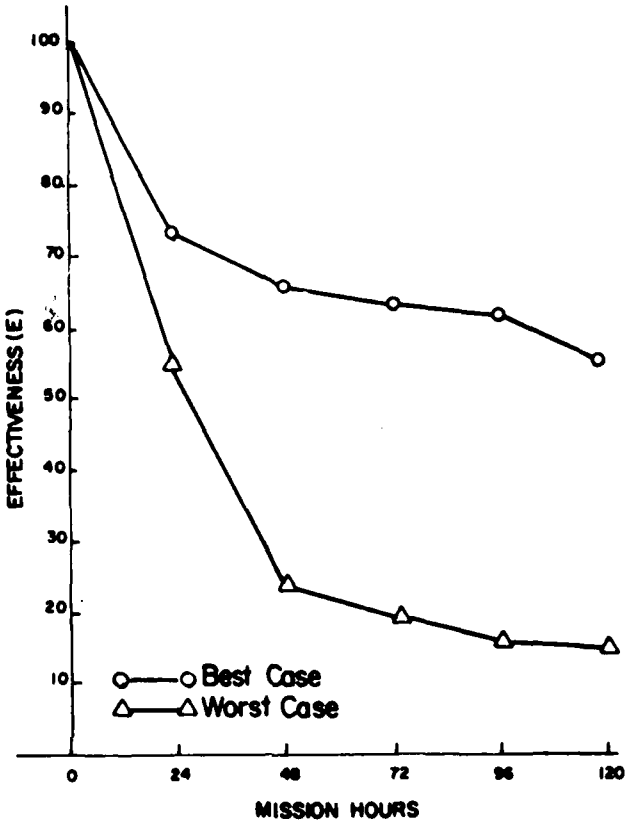


Figure 4.1. Graph of Table 4.7

Table 4.8

Comparisons of Stress for "Best" and "Worst" Cases

Best						Worst					
Maximum Stress Array						Maximum Stress Array					
DAY	MAXST	MAXTM	T	U		DAY	MAXST	MAXTM	T	U	
1	8.34	24.00	1	1	Mechanized	1	3167.07	24.00	1	1	
2	7.33	18.00	1	1		2	5899.31	18.00	1	1	
3	2.00	13.50	1	1	Infantry	3	4673.01	13.50	1	1	
4	0.70	21.00	1	1		4	2814.48	12.60	1	1	
5	6.36	16.70	1	1	Squad	5	941.59	16.70	1	1	
.						.					
.						.					
.						.					
1	3.38	24.00	4	1	Tank	1	1893.57	24.00	4	1	
2	5.36	18.00	4	1		2	4480.78	18.00	4	1	
3	1.41	13.50	4	1	Platoon	3	4155.13	13.50	4	1	
4	0.50	21.00	4	1		4	2567.67	12.60	4	1	
5	5.02	16.70	4	1	Leadership	5	901.74	16.70	4	1	
.						.					
.						.					
.						.					
1	12.52	24.00	6	1	Forward	1	4454.51	24.00	6	1	
2	11.91	18.00	6	1		2	7404.75	18.00	6	1	
3	3.15	13.50	6	1	Observer/RTO	3	4860.00	13.50	6	1	
4	1.11	21.00	6	1		4	2916.00	12.60	6	1	
5	10.71	16.70	6	1	Team	5	972.00	5.40	6	1	
.						.					
.						.					
.						.					
1	13.74	24.00	9	1	Artillery	1	4640.40	24.00	9	1	
2	7.75	18.00	9	1		2	6696.80	18.00	9	1	
3	2.29	13.50	9	1	Battery	3	4813.07	5.50	9	1	
4	0.82	21.00	9	1		4	2916.00	12.60	9	1	
5	7.38	16.70	9	1	Leadership	5	972.00	5.40	9	1	

While the user will want to develop specific output displays to fit his specific need, one final type out plot is frequently useful. Here effectiveness is plotted against variation of a given parameter or set of parameters over a range. Figure 4.2 presents an illustration of how such a plot might appear. Often, superimposing plots for two parameters on the same axis helps to clarify trade off possibilities.

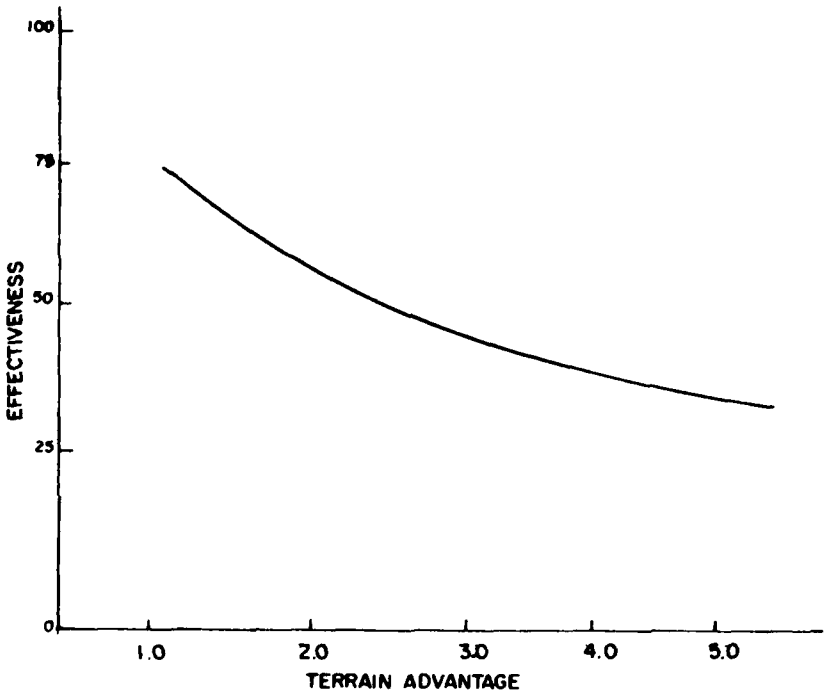


Figure 4.2. Example of plot of effectiveness change as a function of parameter variations

REFERENCES

Pfeiffer, M. G., Siegel, A. I., Taylor, S. E., & Shuler, L. Background Data for the Human Performance in Continuous Operations Guidelines. Alexandria, Virginia: U.S. Army Research Institute for the Behavioral and Social Sciences, 1979.

Siegel, A. I., Pfeiffer, M. G., Kopstein, F. F., Wilson, L., & Ozkaptan, H. Human Performance in Continuous Operations--Volume I. Human Performance Guidelines. Alexandria, Virginia: U.S. Army Research Institute for the Behavioral and Social Sciences, 1979.

APPENDIX A

Graphic Instructions for Running PERFECT Simulation Model

(See Step H, Chapter III)

GRAPHIC INSTRUCTIONS FOR RUNNING PERFECT SIMULATION MODEL

KEY:

OPERATOR INPUT

COMPUTER OUTPUT

R– "RETURN"

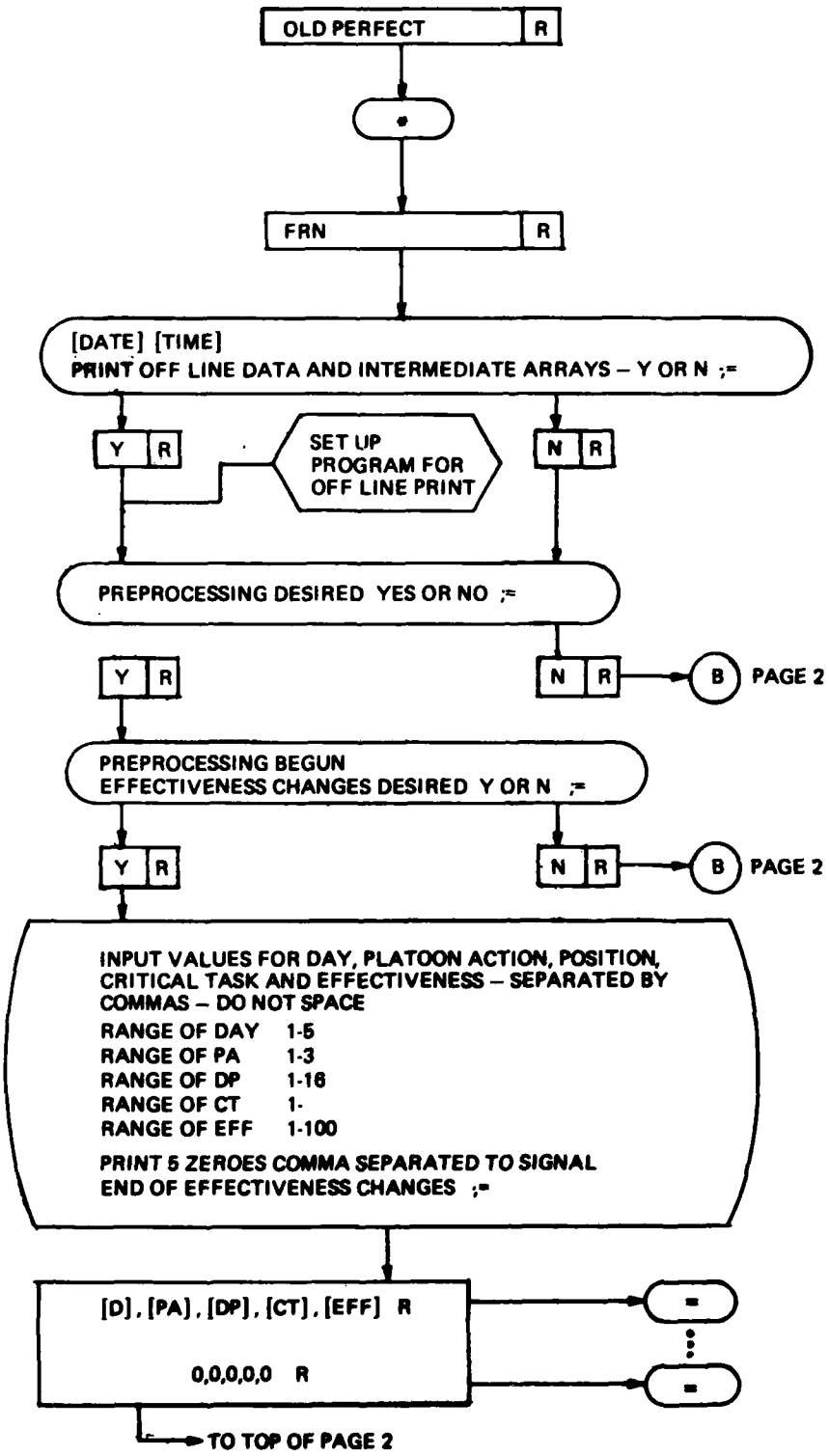
COMPUTER OPERATION

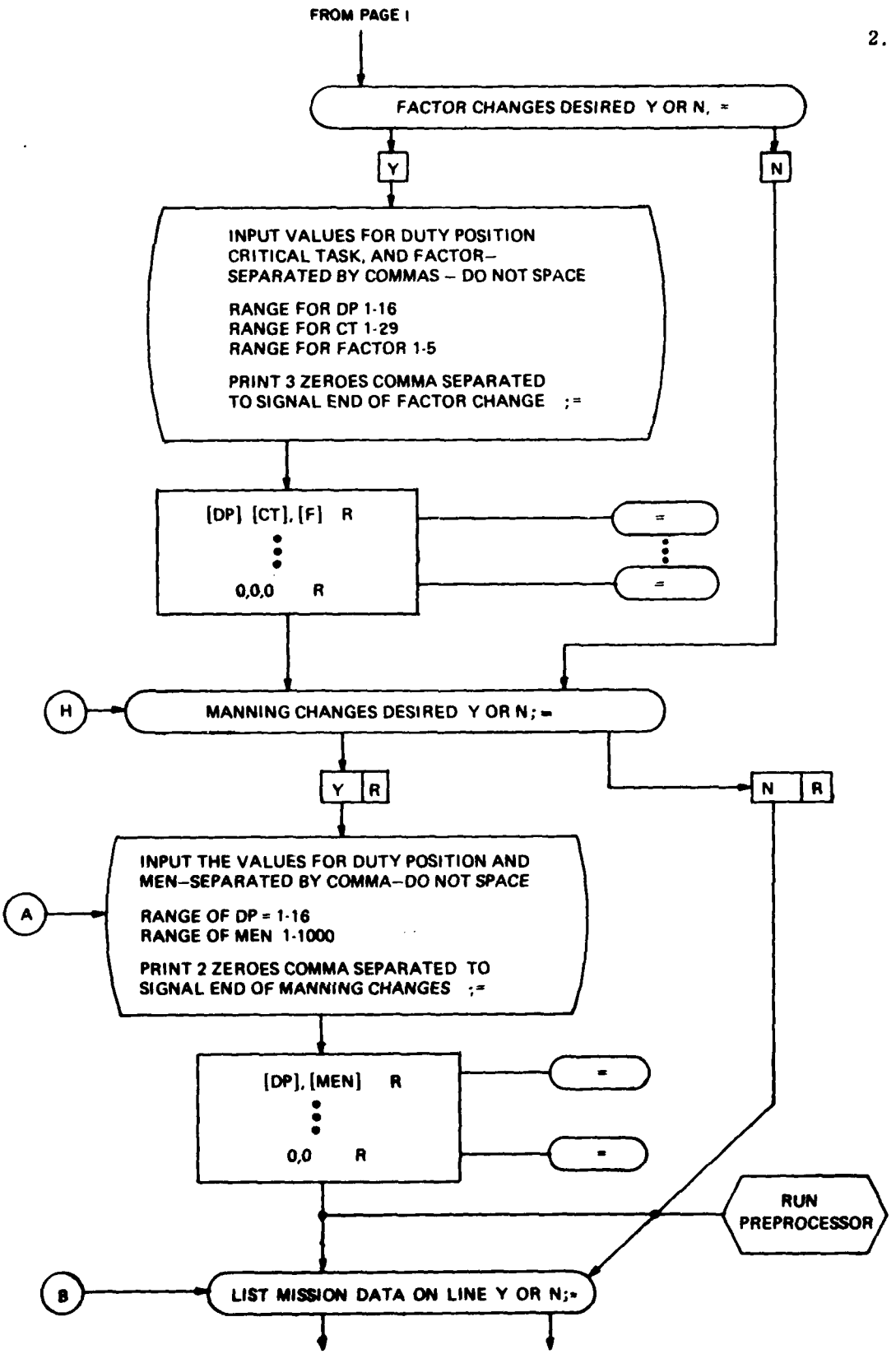
Y– YES

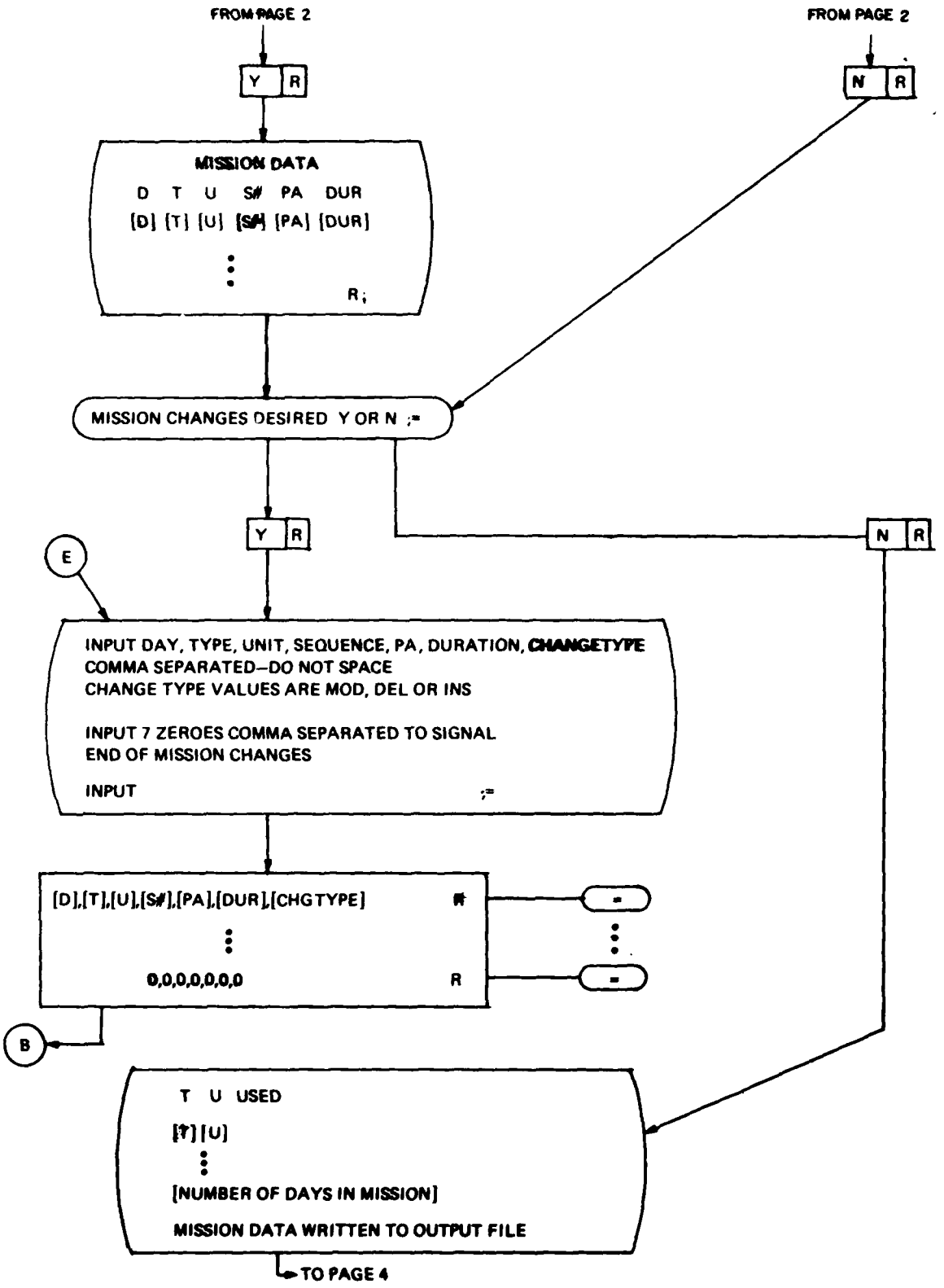
N– NO

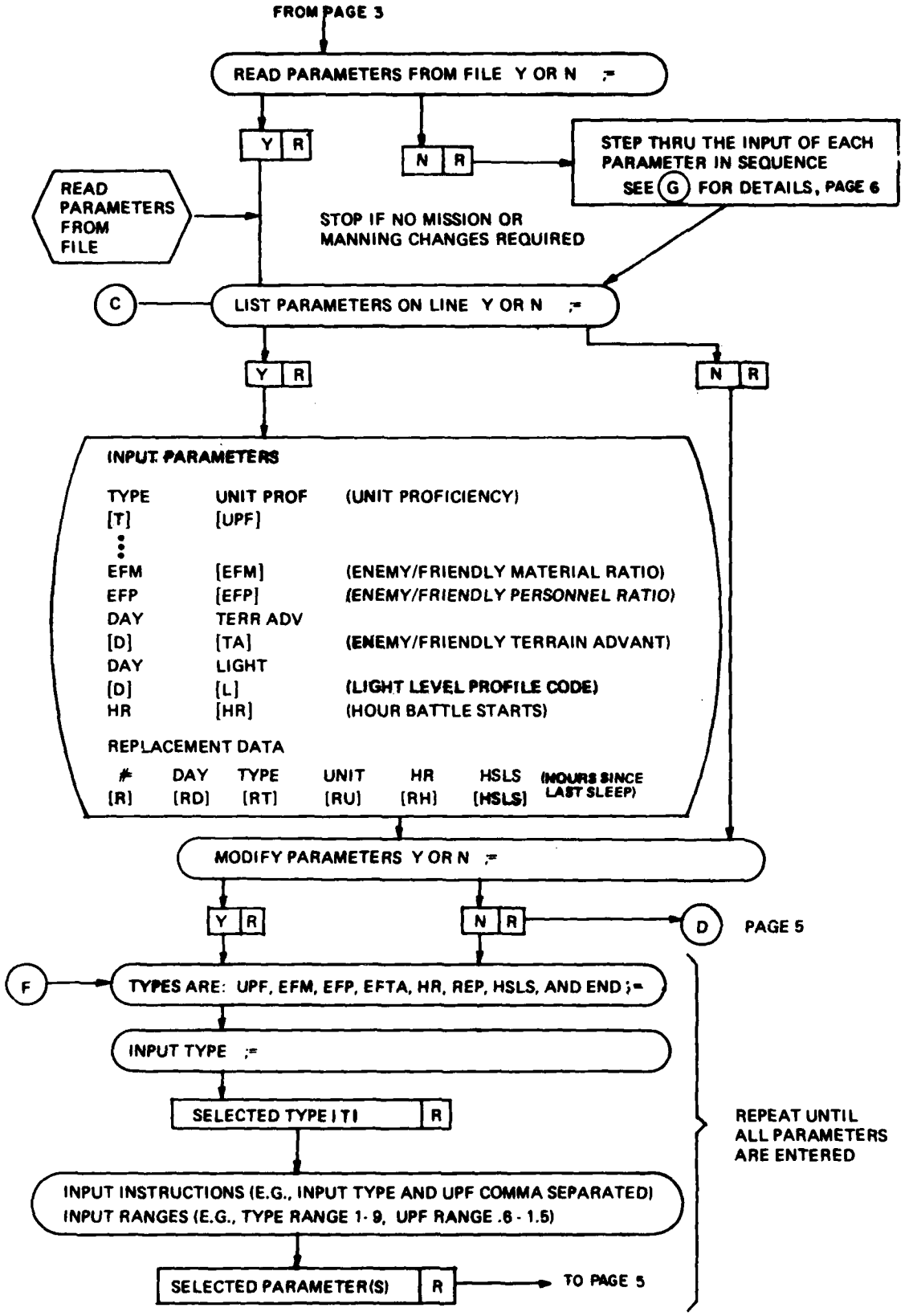
; CARRIAGE RETURN BY COMPUTER

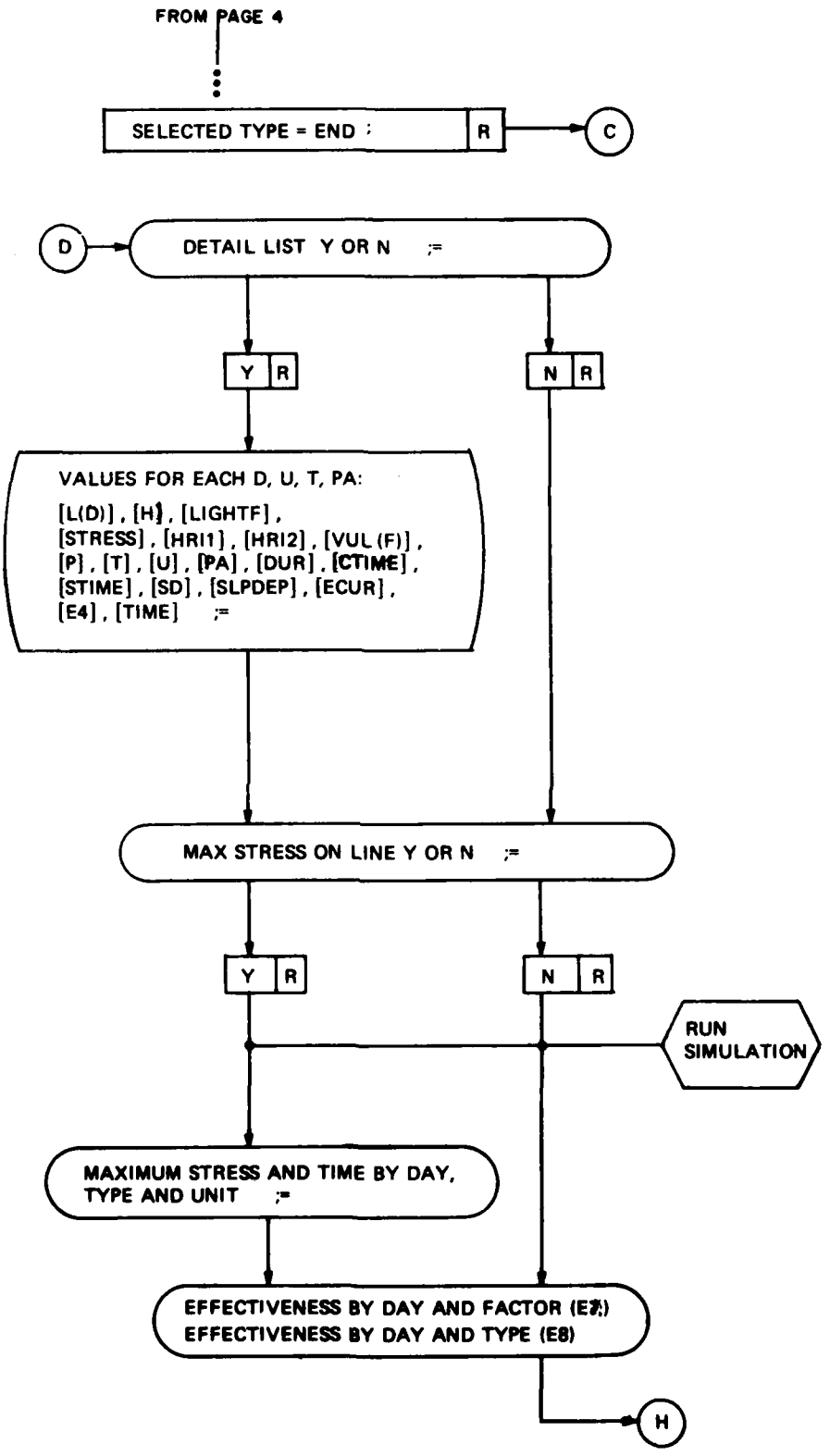
[ ] VALUE OF




FROM PAGE 1
FACTOR CHANGES DESIRED Y OR N, =
Y
N
INPUT VALUES FOR DUTY POSITION
CRITICAL TASK, AND FACTOR–
SEPARATED BY COMMAS – DO NOT SPACE
RANGE FOR DP 1-16
RANGE FOR CT 1-29
RANGE FOR FACTOR 1-5
PRINT 3 ZEROES COMMA SEPARATED
TO SIGNAL END OF FACTOR CHANGE ;=
[DP] [CT], [F] R
0,0,0 R
=
=
H
MANNING CHANGES DESIRED Y OR N; =
Y R
N R
INPUT THE VALUES FOR DUTY POSITION AND
MEN–SEPARATED BY COMMA–DO NOT SPACE
A
RANGE OF DP = 1-16
RANGE OF MEN 1-1000
PRINT 2 ZEROES COMMA SEPARATED TO
SIGNAL END OF MANNING CHANGES ;=
[DP], [MEN] R
0,0 R
=
=
RUN
PREPROCESSOR
B
LIST MISSION DATA ON LINE Y OR N;=
TO TOP OF PAGE 3

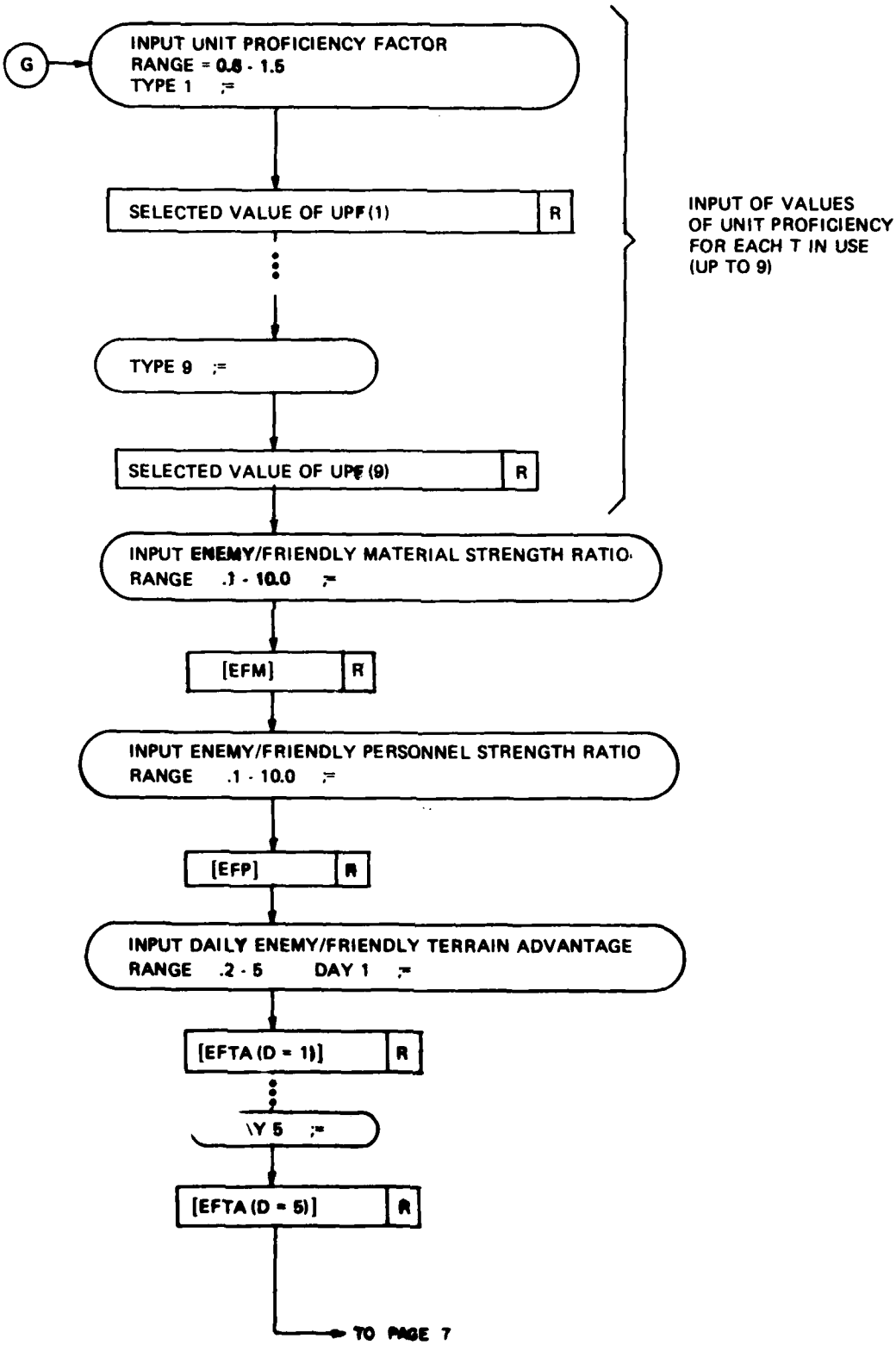

FROM PAGE 2
Y R
MISSION DATA
D T U S# PA DUR
[D] [T] [U] [S#] [PA] [DUR]
R;
FROM PAGE 2
N R
MISSION CHANGES DESIRED Y OR N ;=
Y R
N R
E
INPUT DAY, TYPE, UNIT, SEQUENCE, PA, DURATION, CHANGETYPE
COMMA SEPARATED–DO NOT SPACE
CHANGE TYPE VALUES ARE MOD, DEL OR INS
INPUT 7 ZEROES COMMA SEPARATED TO SIGNAL
END OF MISSION CHANGES
INPUT ;=
[D],[T],[U],[S#],[PA],[DUR],[CHGTYPE] R
0,0,0,0,0,0,0 R
B
T U USED
[T] [U]
[NUMBER OF DAYS IN MISSION]
MISSION DATA WRITTEN TO OUTPUT FILE
TO PAGE 4

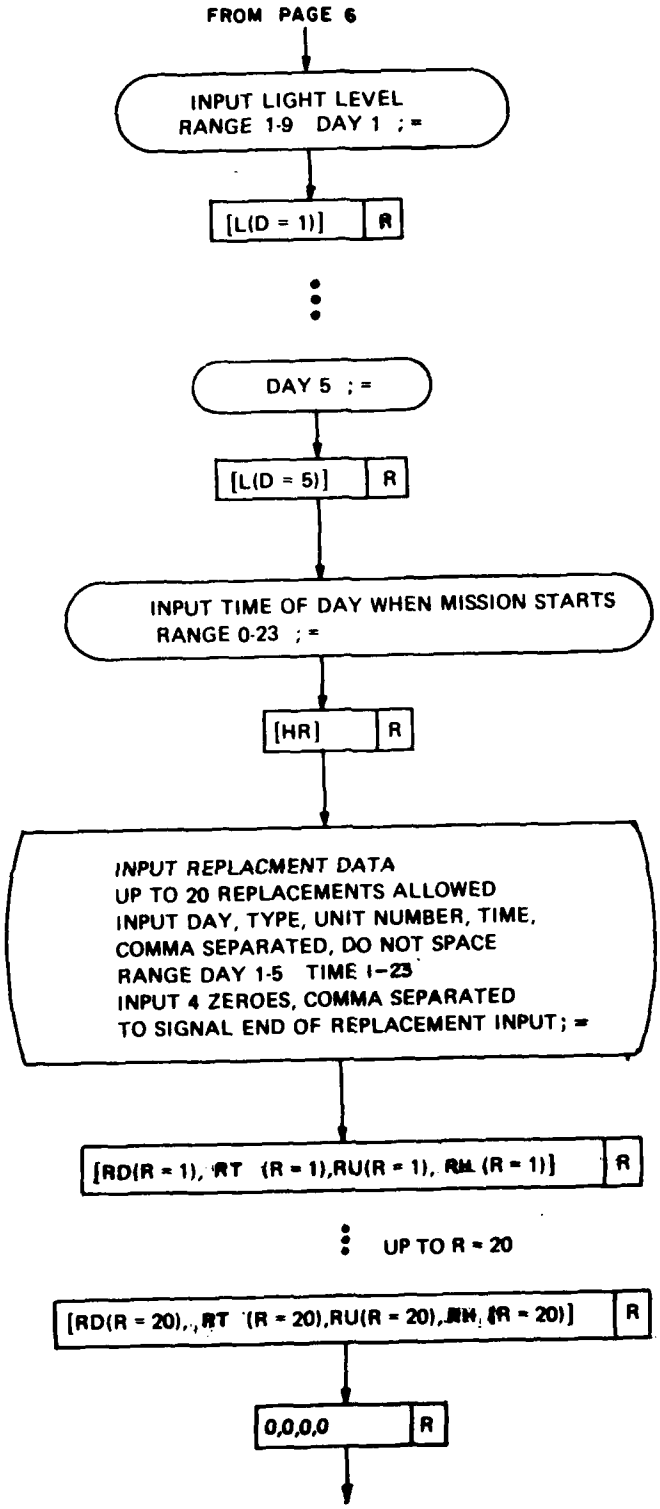

FROM PAGE 3
READ PARAMETERS FROM FILE Y OR N ;=
Y R
N R
STEP THRU THE INPUT OF EACH PARAMETER IN SEQUENCE
SEE (G) FOR DETAILS, PAGE 6
READ PARAMETERS FROM FILE
STOP IF NO MISSION OR MANNING CHANGES REQUIRED
C
LIST PARAMETERS ON LINE Y OR N ;=
Y R
N R
INPUT PARAMETERS
TYPE [T] UNIT PROF [UPF] (UNIT PROFICIENCY)
EFM [EFM] (ENEMY/FRIENDLY MATERIAL RATIO)
EFP [EFP] (ENEMY/FRIENDLY PERSONNEL RATIO)
DAY [D] TERR ADV [TA] (ENEMY/FRIENDLY TERRAIN ADVANT)
DAY [D] LIGHT [L] (LIGHT LEVEL PROFILE CODE)
HR [HR] (HOUR BATTLE STARTS)
REPLACEMENT DATA
[R] DAY [RD] TYPE [RT] UNIT [RU] HR [RH] HSLS [HSLS] (HOURS SINCE LAST SLEEP)
MODIFY PARAMETERS Y OR N ;=
Y R
N R
D
PAGE 5
F
TYPES ARE: UPF, EFM, EFP, EFTA, HR, REP, HSLS, AND END ;=
INPUT TYPE ;=
SELECTED TYPE [T] R
INPUT INSTRUCTIONS (E.G., INPUT TYPE AND UPF COMMA SEPARATED)
INPUT RANGES (E.G., TYPE RANGE 1-9, UPF RANGE .6 - 1.5)
SELECTED PARAMETER(S) R
TO PAGE 5
REPEAT UNTIL ALL PARAMETERS ARE ENTERED


FROM PAGE 4
SELECTED TYPE = END ;
R
C
D
DETAIL LIST Y OR N ;=
Y
R
N
R
VALUES FOR EACH D, U, T, PA:
[L(D)], [H], [LIGHTF],
[STRESS], [HRI1], [HRI2], [VUL(F)],
[P], [T], [U], [PA], [DUR], [CTIME],
[STIME], [SD], [SLPDEP], [ECUR],
[E4], [TIME] ;=
MAX STRESS ON LINE Y OR N ;=
Y
R
N
R
RUN SIMULATION
MAXIMUM STRESS AND TIME BY DAY, TYPE AND UNIT ;=
EFFECTIVENESS BY DAY AND FACTOR (E7)
EFFECTIVENESS BY DAY AND TYPE (E8)
H

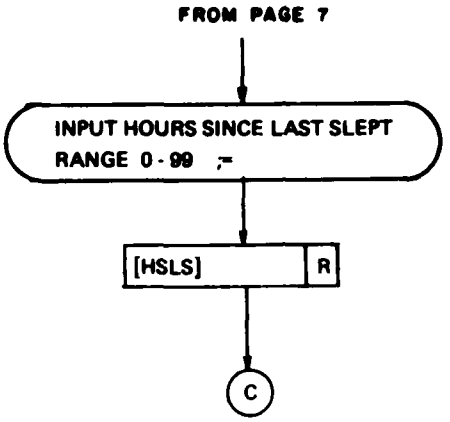
TO PAGE 6

FROM PAGE 4


G
INPUT UNIT PROFICIENCY FACTOR
RANGE = 0.8 - 1.5
TYPE 1 :=
SELECTED VALUE OF UPF(1)
R
TYPE 9 :=
SELECTED VALUE OF UPF(9)
R
INPUT OF VALUES
OF UNIT PROFICIENCY
FOR EACH T IN USE
(UP TO 9)
INPUT ENEMY/FRIENDLY MATERIAL STRENGTH RATIO
RANGE .1 - 10.0 :=
[EFM]
R
INPUT ENEMY/FRIENDLY PERSONNEL STRENGTH RATIO
RANGE .1 - 10.0 :=
[EFP]
R
INPUT DAILY ENEMY/FRIENDLY TERRAIN ADVANTAGE
RANGE .2 - 5 DAY 1 :=
[EFTA(D = 1)]
R
\Y 5 :=
[EFTA(D = 5)]
R
TO PAGE 7


FROM PAGE 6
INPUT LIGHT LEVEL
RANGE 1-9 DAY 1 ; =
[L(D = 1)]
R
DAY 5 ; =
[L(D = 5)]
R
INPUT TIME OF DAY WHEN MISSION STARTS
RANGE 0-23 ; =
[HR]
R
INPUT REPLACMENT DATA
UP TO 20 REPLACEMENTS ALLOWED
INPUT DAY, TYPE, UNIT NUMBER, TIME,
COMMA SEPARATED, DO NOT SPACE
RANGE DAY 1-5 TIME 1-23
INPUT 4 ZEROES, COMMA SEPARATED
TO SIGNAL END OF REPLACEMENT INPUT; =
[RD(R = 1), RT (R = 1),RU(R = 1), RH (R = 1)]
R
UP TO R = 20
[RD(R = 20), RT (R = 20),RU(R = 20), RH (R = 20)]
R
0,0,0,0
R
TO PAGE 8

8.



APPENDIX B

Simulation Program Description

Simulation Program Description

This Appendix includes a technical summary of the logic and features of the PERFECT simulation model.

Principal subscripts, indicating the scope/size of the model are given in Table B.1.

Inputs to the model consist of the six data arrays shown in Table B.2 plus the parameters described in Chapter II, Step D.

The Preprocessor Module

The preprocessing is completed in four major stages. These stages provide the data for the main simulation processing and reduce the calculational complexity during that stage. Prior to these four steps of arithmetic processing, the preprocessor allows interactively for changes to be made in the data arrays. This is accomplished via a menued sequence of choices and questions presented in Chapter II. Range of value checks for all inputs are made by the program.

Starting with the effectiveness matrix, the values for the end of each day (D) for each platoon action (PA), duty position (DP), and critical task (CT), a smaller matrix is computed whose elements are the geometric mean of the effectiveness values for each of the five factors. The result is a matrix E2 (D, PA, DP, F) of the form:

Factor (F)	DP = 1				DP = 16		
	PA = 1 D = 1-5	. . .	PA = 3 D = 1-5	. . .	PA = 1 D = 1-5	. . .	PA = 3 D = 1-5
1							
2							
3							
4							
5							

For any DP having no instances of a given factor, the resulting value of E2 is specially identified so that such instances are not tallied into the averages calculated in the next step.

Table B.1

Major Subscripts

Subscript	Meaning	Other Names & References	Value Range
CT	Critical task number	Appendix D&E	1-29
D	Day number	IDAY	1-5
DP	Duty position number	IDP, Table 2.1	1-16
F	Factor	FAC, Table 2.10	1-5
H	Hour number		0-23
L	Light level profile no.	Table 2.8	1-9
PA	Platoon action number	IPA, Table 2.3	0-3
R	Replacement number		1-20
T	Type of combat unit	Table 2.1	1-9
U	Combat unit number	Table 2.1	1-5

Table B.2

Data Arrays

No.	Data Array	FORTRAN Name	Value Range	Data Requirement
1	Factor number(s) for each critical task	F (DP,CT)	1-5	P
2	Effectiveness at end of each day	E(D,PA,DP,CT)	1-100	P
3	Manning table, number of troops for each duty position, see Table 2.1	MEN(DP)	1-10	P
4	Light level values for each hour of 9 preset type of day situations	LIGHT (L,H)	1-9	M
5	Fraction of critical tasks for each factor by unit type, see Table B.3	FTYPE (F,T)	0-0.999	M
6	Mission Data:			
	Platoon Action	PA (D,T,U,S)	0-3	M
	Duration (Hours)	DUR (D,T,U,S)	0.1-24.0	
	Day	D	1-5	
	Combat unit type	T	1-9	
	Combat unit number	U	1-5	
	Sequence number	S	1-24	

P - Preprocessor

M - Main Program

In stage 2, the manning input data are applied to the matrix resulting from stage 1 and another matrix E3 (D, PA, F, T) is calculated by averaging over all duty positions according to the equation:

$$\frac{\text{MEN (DP) X E2 (D, PA, DP, F)}}{\sum_{T} \text{MEN (DP, T)}} \rightarrow \text{E3 (D, PA, F, T)}$$

The resultant E3 (D, PA, F, T) matrix has the following form:

Factor (F)	Unit Type 1				Unit Type 9		
	PA = 1 D = 1 - 5	. . .	PA = 3 D = 1 - 5	. . .	PA = 1 D = 1 - 5	. . .	PA = 3 D = 1 - 5
1							
2							
3							
4							
5							

The third stage is the translation of matrix E3 (D, PA, F, T) into another matrix E4 (D, PA, F, T) in which each element represents the unit degradation in effectiveness per hour for all values of D, PA, F, and T as follows:

$$\text{E4 (D, PA, F, T)} = \frac{\text{E3 (D - 1, PA, F, T)} - \text{E3 (D, PA, F, T)}}{24}$$

Both matrices E3 and E4 have the same format, yet E3 contains values of effectiveness and E4 contains values of decreases in effectiveness per hour.

During the fourth and last stage of the preprocessing, the data for day 6 are added to the E4 (D, PA, F, T) matrix by linear extrapolation.

$$\text{E4 (D = 6, PA, F, T)} = \text{E4 (D = 5, PA, F, T)} -$$
$$\left[\text{E4 (D = 4, PA, F, T)} - \text{E4 (D = 5, PA, F, T)}\right]$$
$$\text{E4 (D = 6, PA, F, T)} = 2\,\text{E4 (D = 5, PA, F, T)} - \text{E4 (D = 4, PA, F, T)}$$

Although the simulation per se is limited to five days, data for day six are required in order to simulate conditions of stress on day five.

Note that preprocessing is normally required only when the manning table is altered, since it is not expected that values of the original effectiveness table or the factor table will change.

Mission Load Module

The mission load module consists of an extensive set of menued alternatives which allows the analyst to identify parameter values in response to requests. Input values are verified to fall in the allowed range or are rejected.

Main Processing Module

The main processing module is generally repetitive in its processing. It proceeds sequentially through the operation in time from the start to the end of the data. The processing is based on the effectiveness data from the E4 matrix and is recycled in turn for the following sequential information from the mission input:

Mission Data Element	Element Symbolics
Day	D
Unit Type	T = 1 of 9
Unit Number of This Type	U = 1 of 5
Platoon Action Number	PA (D, U, T) = 0 to 3
Duration (hours) of the Platoon Action	DUR (D, T, U, S) = 0 to 24
Sequence Number	S = 1, 2, . . . within each U, T pair.

The mission input data consist of sets of these data (see Table 2.4) representing 24 hour days (except the last day). Accordingly, the operation may be initiated at any time of day or night (by the HR parameter) and its duration specified by mission data inputs. During the processing, the program calculates and keeps track of the following variables for each such quartet:

- current value of effectiveness, ECUR (F, D, T, U)
- current value of time (days and hours), CTIME
- current value of the stress factor, STRESS F(T, U)
- a value of time change corresponding to that stress condition, called "stress time," STIME (T, U)
- length of time since last sleep, SLPDEP (T, U)

Prior to the start of simulation the following variables are initialized:

STIME (T, U)	= 0	stress time
SD (T, U)	= 1	stress day

CTIME	= 0	current time
ECUR (F, D, T, U)	= 1 (for D 1)	current effectiveness
D	= 0	day number
R	= 1	replacement sequence number
SLPDEP (T, U)	= HSLS	sleep deprivation
STRESS (T, U)	= 0	stress value
MAXSTR1 (D, T, U)	= 0	maximum stress
MAXTIM1 (D, T, U)	= 0	time of maximum stress

In order to make the scaling of UPF(T) approximately the same as EFM and EFP, the following adjustments are made to each UPF(T) value before simulation processing:

$$\text{if } UPF(T) \leq 1,\ UPF(T) = \frac{UPF(T)}{6},\ \text{range 0.1 to 1.0}$$

$$\text{if } UPF(T) > 1,\ UPF(T) = 6\,UPF(T),\ \text{range 1.0 to 9.0}$$

Current Value of Time

The current value of time CTIME for the combat unit under consideration is obtained by adding the current platoon action duration to a running total of the unit's prior time preset to zero at the start of the continuous operation simulation. Length of time since last sleep is handled similarly, but preset at the start of the action to the value of the "hours since sleep" parameter.

$$CTIME = CTIME + DUR\ (D,\ T,\ U,\ S)$$

Current Value of Stress

The current value of the stress factor depends on the parameters: light factor LIGHTF(D), enemy/friendly personnel strength ratio (EFP), enemy/friendly material strength ratio (EFM), enemy/friendly terrain advantage (EFTA), proficiency of the combat unit UPF(T), and a variable called "vulnerability" which is represented by (1 – Efficiency):

$$STRESSF(T, U) = EFM \cdot EFP \cdot LIGHTF(D) \cdot UPF(T) \cdot EFTA(D) \cdot VUL(F)$$

Previously VUL(F) is calculated as $VUL(F) = 5\,[1 - ECUR\ (F, D, T, U)]$ for F = 1 through 5. This function is shown in Figure B. 1 and allows values of vulnerability from 0 to 5.

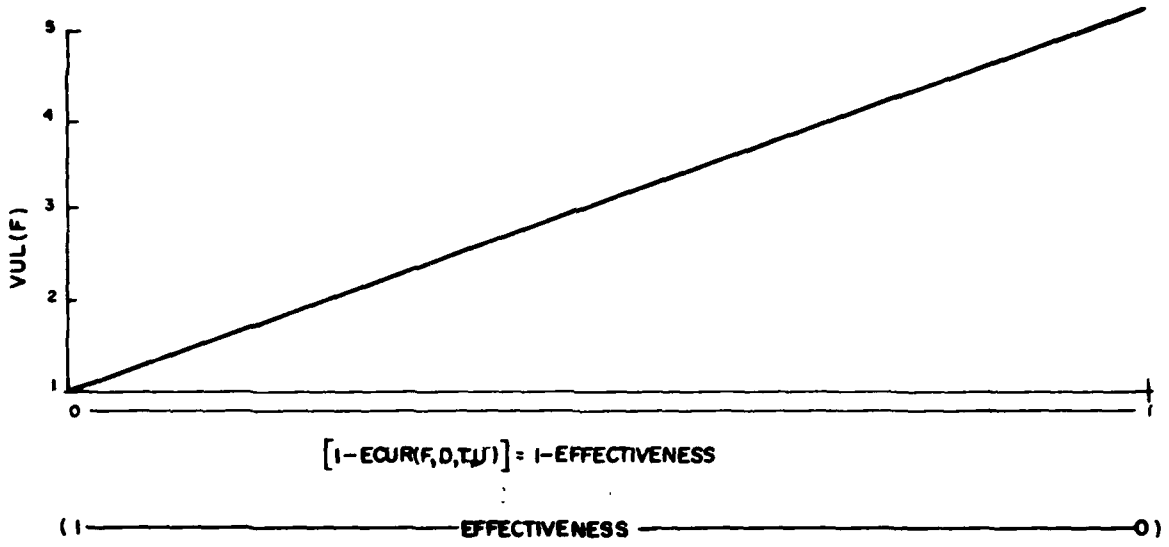


Figure B.1. Calculation of vulnerability

A final (single) value of stress is calculated for the five factor values of STRESSF(F) by applying a series of weights calculated from an analysis of the number of critical tasks within each factor by type of combat units. The numbers are given in Table B. 3 (a) and the weights called FTYPE (T, F) in Table B. 3 (b). Thus:

$$\text{STRESS}(T, U) = \sum_{F=1}^{5} \text{STRESSF}(F) \cdot \text{FTYPE}(F, T)$$

The maximum value of STRESSF (T, U) for each day, unit, and type is saved for optional output at the completion of the simulation.

The following calculations are required to determine the value of the light factor (LIGHTF) used in determining STRESS (T, U). The value of LIGHTF is determined by Table B. 4 based on the input parameter L (see Table 2. 8) and the time of day, H, of the midpoint of the platoon action. Here:

$$H = \text{CTIME} + \text{HR} - \text{DUR}(D, T, U, S)/2$$

where HR is the input parameter (hour mission starts) and DUR (D, T, U, S) is the platoon action duration. Given H and L, a value of LIGHT (L, H) is obtained from the 9 X 24 matrix of light level values given in Table 2. 7. With this value of LIGHT (L, H), the model selects a value for LIGHTF from Table B. 4.

Table B. 4

Light Factor

LIGHT (L, H)	LIGHTF
1	3.0
2	2.7
3	2.4
4	2.1
5	1.8
6	1.6
7	1.4
8	1.2
9	1.0

Table B. 3

Number of Critical Tasks Associated with Each Factor

(a)

Unit Type T	Factor 1	2	3	4	5
1	17	20	4	5	3
2	13	2	7	5	0
3	2	11	8	4	7
4	4	2	4	2	14
5	1	10	1	2	3
6	17	1	4	3	3
7	14	9	3	1	4
8	5	5	6	4	22
9	5	1	0	0	0

(b)

Weight of Critical Tasks Associated With Each Factor FTYPE(T,F)

1	.347	.408	.082	.102	.061
2	.481	.074	.259	.185	0
3	.063	.344	.250	.125	.219
4	.154	.077	.153	.077	.538
5	.059	.588	.059	.118	.176
6	.607	.036	.143	.107	.107
7	.452	.290	.097	.032	.129
8	.119	.119	.143	.095	.524
9	.833	.167	0	0	0

Stress Affects

When the stress factor increases, the model takes account of this by effectively jumping the time ahead for the affected combat unit to simulate troops having a lower effectiveness value. The amount of this jump is a function of the magnitude of the stress factor. It varies linearly from a value of zero (for stress factor equal to zero) up to a maximum jump of 24 hours if the stress factor has a value of 25 or more. This pseudo time variable is called "stress time" and the result is poorer (lower) effectiveness as a result of stress.

The amount of the jump is called HRI (hour increment) as shown in Figure B.2. This calculation is accomplished for the current values (HRI 2) and subtracted from the value for this U, T on its prior platoon action (i.e., HRI 1). To obtain the value of stress affect, STA = HRI 2 - HRI 1. The resulting value of stress time is then:

$$\text{STIME}(T, U) = \text{STIME}(T, U) + \text{STA} + \text{DUR}(D, T, U, S).$$

However, if STIME (T, U) > 24, the program adjusts to the next day by setting STIME (T, U) = STIME (T, U) − 24 and stress day, SD (T, U) = SD (T, U) + 1 and SDAY = SD (T, U).

Current Level of Effectiveness

The current effectiveness level at the end of the platoon action is calculated as:

$$\text{ECUR}(F, D, T, U) = \text{ECUR}(F, D, T, U) - \text{E4}(D, PA, F, T)\ [\text{DUR}(D, T, U, S)]$$

This indicates that the value of current effectiveness equals the prior value less the product of the effectiveness degradation per hour for the current stress day and the duration of the platoon action. This completes the ECUR calculation if there has been no increase in stress for U, T, i.e., if STA is zero. However, if STA is not zero, adjustments must be made to take this stress increase into account (and if the effective stress time carries over to the next day, to incorporate the proper E4 value for SD). This is accomplished by the following additional logic:

If CTIME + STA ≤ 24 (i.e., if the additive remains within Day D):

$$\text{ECUR}(F, D, T, U) = \text{ECUR}(F, D, T, U) - \text{E4}(D, PA, F, T)\ [\text{STA}].$$

If CTIME + STA ≥ 24 (i.e., if the additive carries over into D+1):

$$\text{ECUR}(F, D, T, U) = \text{ECUR}(F, D, T, U) - \text{E4}(F, D, T, U)\ [24 - \text{CTIME}] - \text{E4}(SD, PA, F, T)\ [\text{STIME}(T, U)].$$

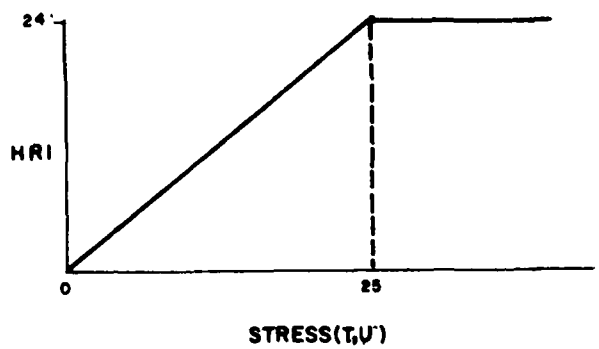


Figure B.2. Time increment due to stress

Sleep

If the current platoon action is not a sleep event, then the current value of sleep deprivation is the sum of the prior deprivation plus the PA duration:

$$SLPDEP(T, U) = SLPDEP(T, U) + DUR(D, T, U, S)$$

However, if a combat unit is scheduled for sleep (i.e., if input PA type = 0 for a combat unit), and if the number of hours of sleep deprivation SLPDEP (T, U) is less than 16, then the processing includes the calculation of the following additional variables which replace those previously described for combat actions.

- number of hours sleep required for 100% recovery from sleep deprivation,

$$RECOVH = \frac{1}{0.03494} \ln \frac{SLPDEP(T, U)}{4.6949}$$ (see Figure B.3)

- percentage recovery time of this sleep,

$$PERREC = \frac{DUR(D, T, U, S)}{RECOVH}$$

- percentage of normal function recovered by this sleep,

$$PERNORM = (PERREC)^{0.5}$$ (see Figure B.4)

- number of effective hours decrease in stress time as a result of this sleep,

$$EFFECT = (PERNORM)(SLPDEP(U, T))$$

- stress time,

$$STIME(T, U) = STIME(T, U) - EFFECT$$

if STIME (T, U) ≤ 0, then SDAY = SD (T, U) = SD (T, U) + 1 and STIME (T, U) = 24 + STIME (T, U)

- current effectiveness,

if EFFECT − CTIME (T, U) < 0, then all changes occur in same day. In this case, ECUR (F, D, T, U) = ECUR (F, D, T, U) + E4 (D, PA, F, T) [EFFECT] for F = 1, . . . 5 otherwise ECUR (F, D, T, U) = ECUR (F, D, T, U) + E4 (D, PA, F, T) [CTIME] + E4 (SDAY, PA, F, T) [EFFECT − CTIME] F = 1, . . . 5

- sleep deprivation,

$$SLPDEP(T, U) = SLPDEP(T, U) \; [(1 - PERREC) \geq 0]$$

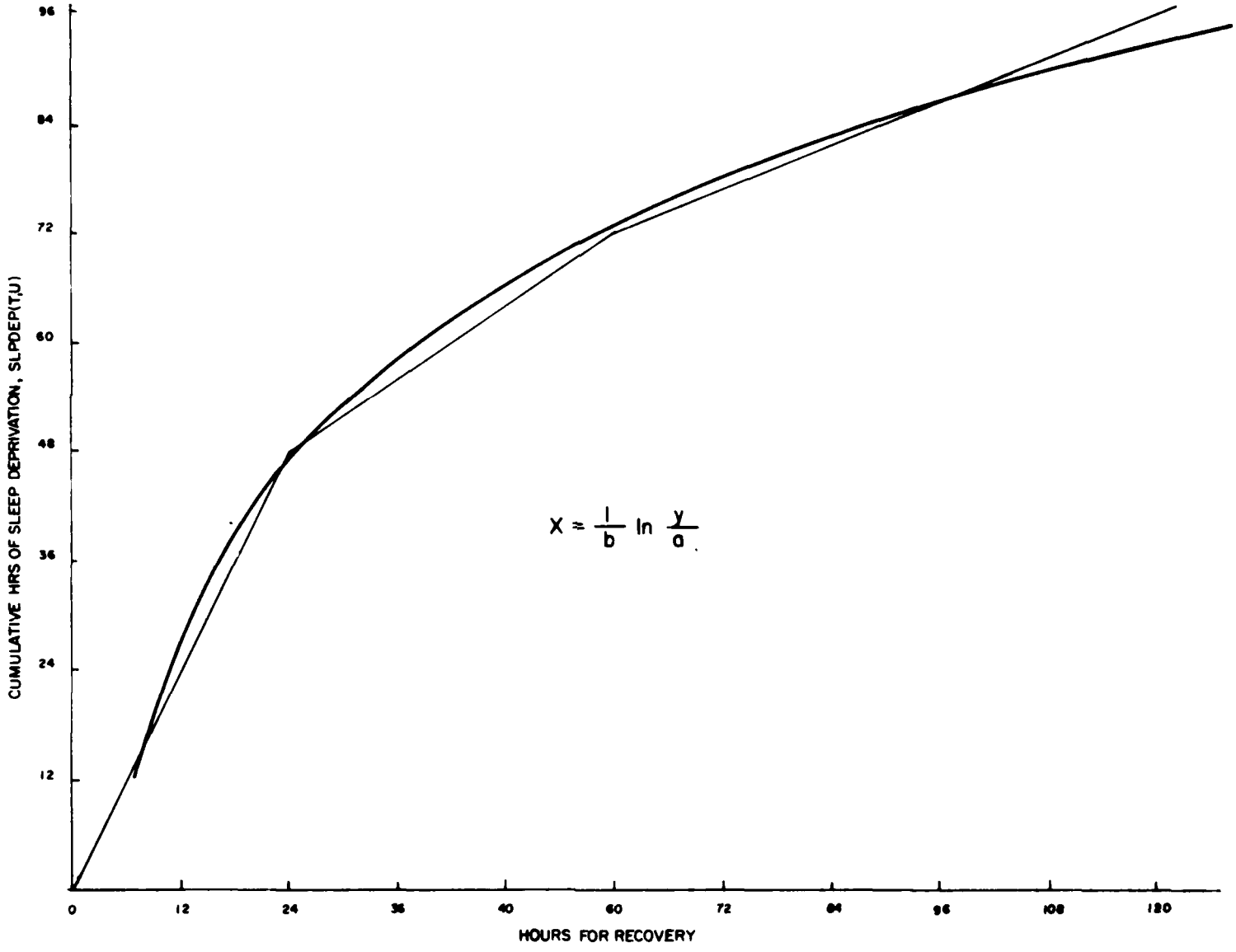


Figure B.3. Hours needed to 100% recovery, RECOVH
(From: Woodward & Nelson, 1974)

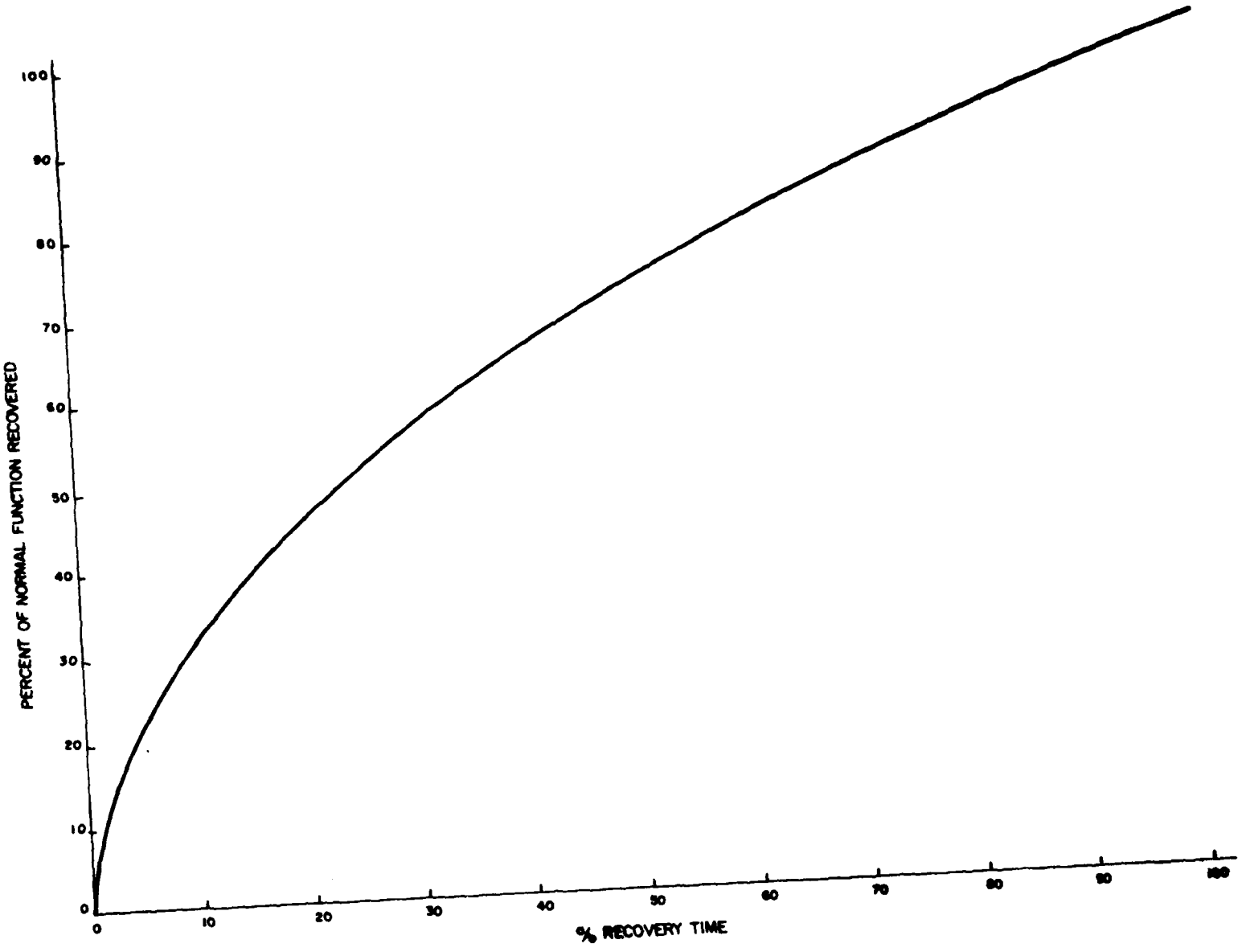


Figure B-4. Performance recovery function, form $y = x^{0.5}$

End of Day Effectiveness

At the end of each day's calculation, the elements of ECUR (F, D, T, U) are the end-of-day effectiveness values for each day, factor, unit type, and unit. It is helpful to conceptualize this matrix as being of the following form:

Factor (F)	Combat Unit Type 1				Combat Unit Type 9		
	U = 1 D = 1 - 5	. . .	Last U D = 1 - 5	. . .	U = 1 D = 1 - 5	. . .	Last U D = 1 - 5
1							
2							
3							
4							
5							

Personnel Replacement

A replacement operation is made whenever, during the main processing module calculations, a condition is reached corresponding to a specified unit, unit type, day, and time when the analyst has specified replacement of that unit in the original parameter input data. Entry into this matrix allows appropriate adjustment of variables to represent the replacement (platooning) of the selected unit by a fresh one, i.e., one for whom conditions (sleep deprivation, effectiveness, etc.) are the same as for the simulated personnel at the start of the operation. The model presently allows up to 20 such unit replacements during simulated continuous operations. If a replacement of combat personnel (of the type assigned to this platoon action) is specified by the input data (i.e., if RT(R) = T, RU(R) = U, RD(R) = D, and RH(R) ≤ CTIME), then:

(1) stress time is reset : STIME(T, U) = 0, SD(T, U) = 1

(2) effectiveness is reset to 1 : ECUR(F, D, T, U) = 1 (all F)

(3) sleep deprivation is reset : $SLPDEP(T, U) = \frac{2\,HSLS}{3}(1 - RN)$

(4) the next replacement is set : R = R + 1

Data Summary

The output portion of the program operates on the ECUR (F, D, T, U) matrix after all mission data have been completely processed by the main processing module. Its principle operations are averaging ECUR (F, D, T, U)

matrix values and providing either for listing these data on a line printer or terminal. First, end of day effectiveness values are averaged over all units of a given type. This yields a matrix E6 (F, D, T) of the following form:

Factor (F)	Unit Type 1 D=1 . . . 5	. . .	Unit Type 9 D=1 . . . 5
1			
2			
3			
4			
5			

Model Output

Using the E6 (F, D, T) matrix, the model generates two additional but smaller tables for listing. These are E7 (F, D) and E8 (D, T) which show end of day effectiveness values by factors and by combat unit type respectively. Table 3.1 shows the formats of these matrices by example.

Also reported as output are maximum values of the stress as they occur during the simulation. The maximums are retained in storage for each unit type and are available in listed table form by the day after each simulation run. The output table contains the following information about the stress factor peak values: unit type number (T), day number (D), stress factor value (MAXST), time of day (MAXTM), and unit number (U). An example of this output is shown in Chapter III, Step K.4.

APPENDIX C

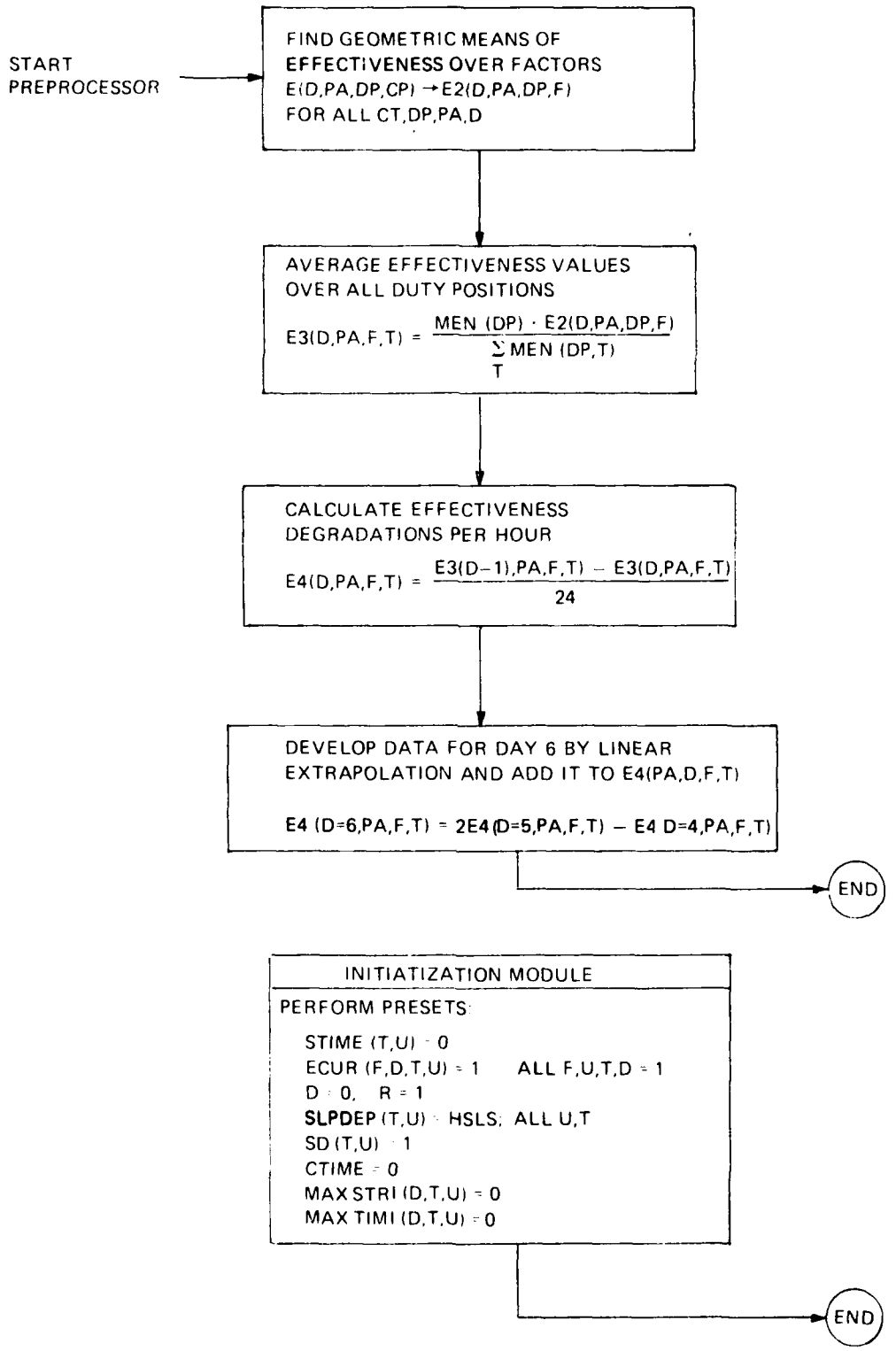
(a) List of Program Subroutines

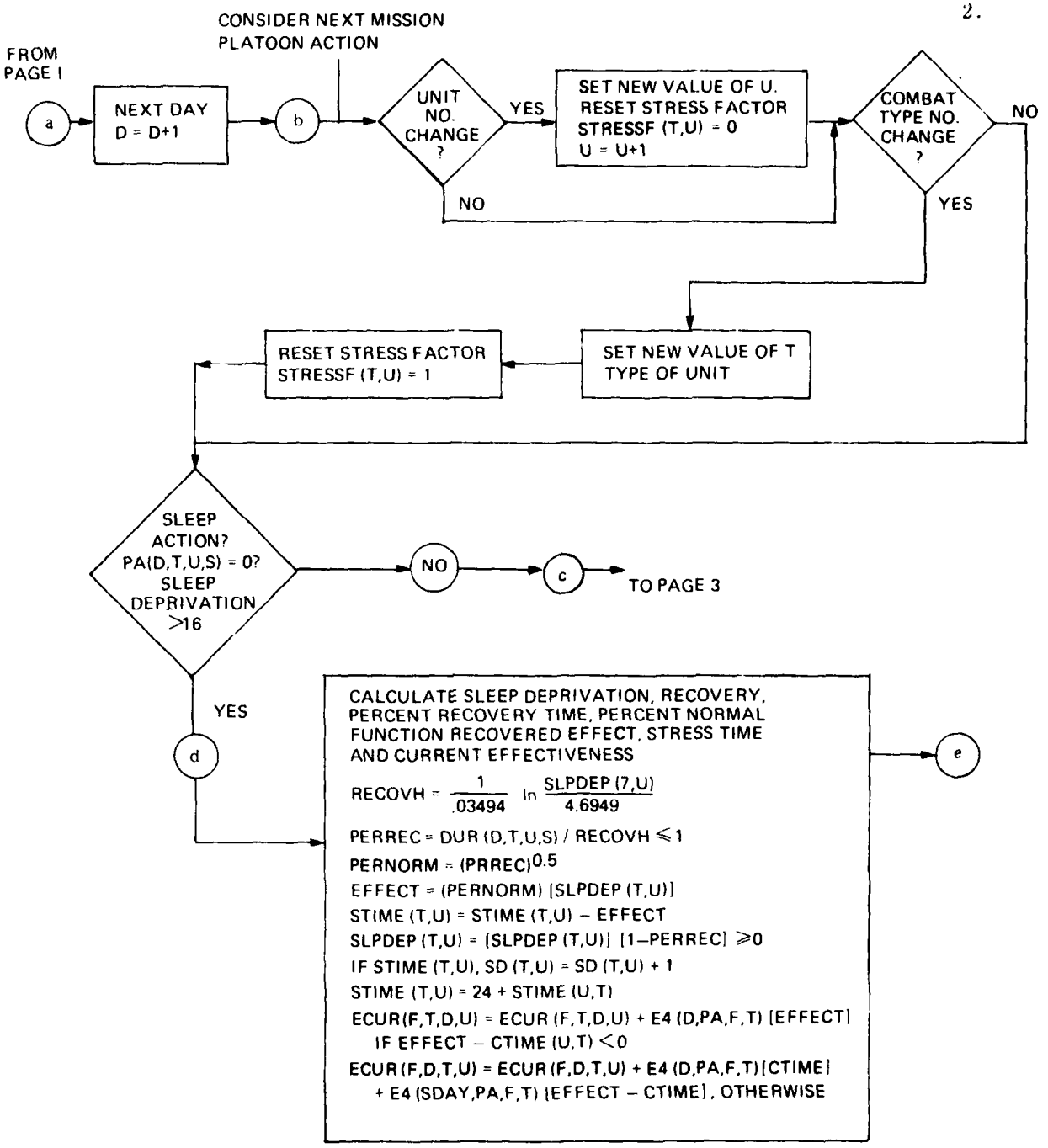
(b) General Flow Chart of Simulation Subroutine

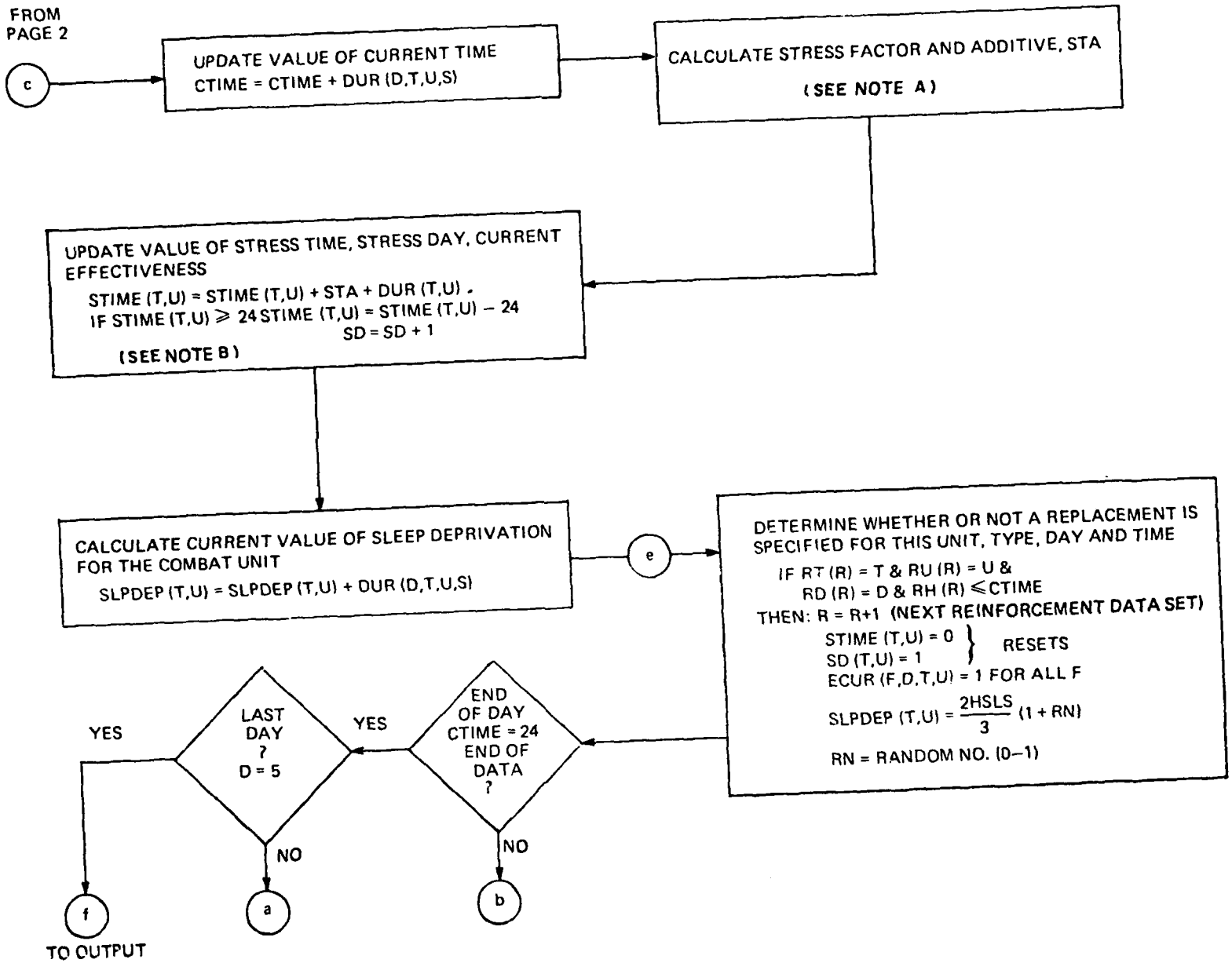
(a) List of Program Subroutines

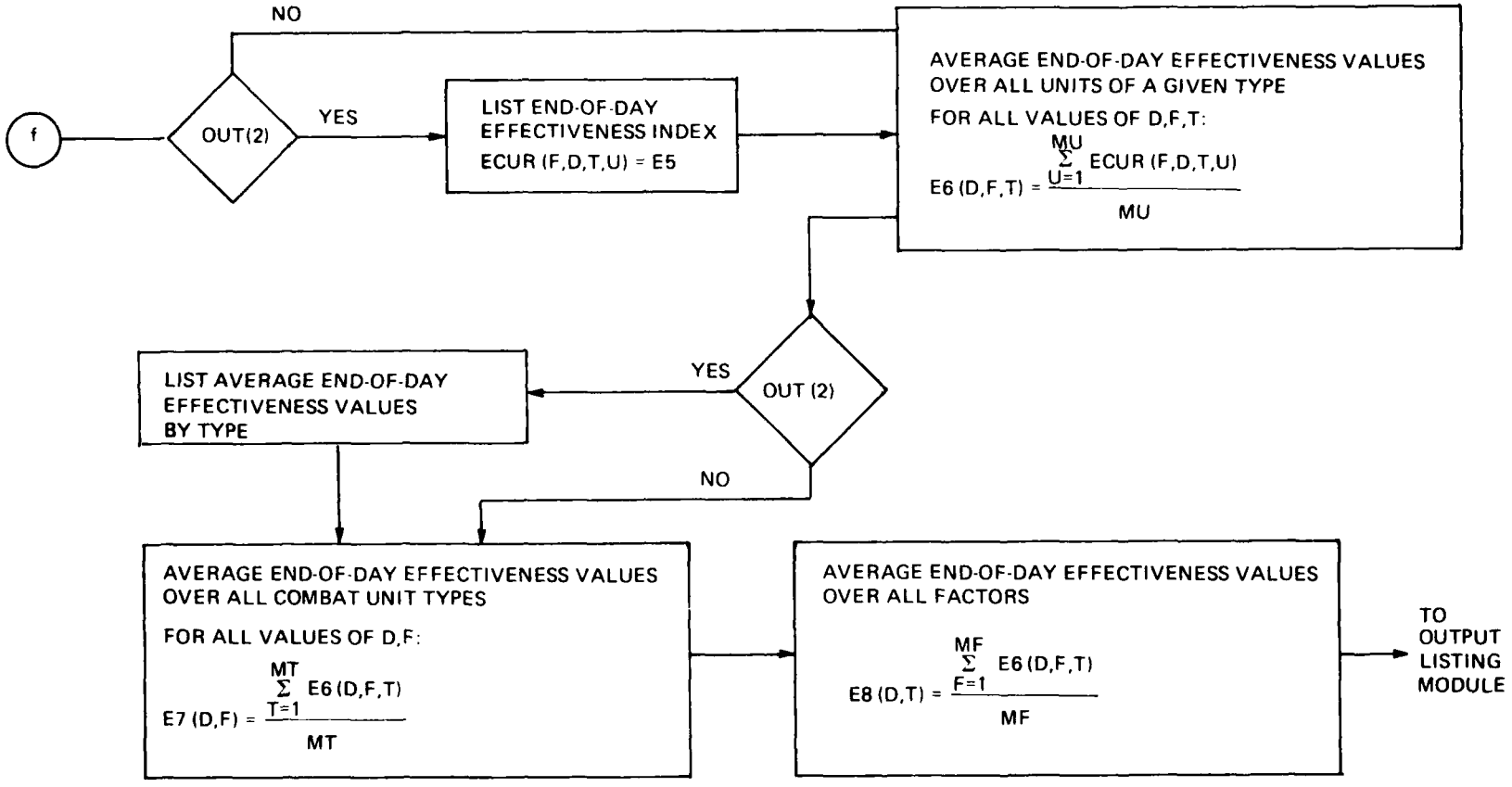
Subroutine Name	Function
CFPARA	Create parameter file
CALCHRI	Calculate HRI
INPMISS	Mission inputs
INPUT	Control parameter input
MDPARA	Modify parameters
OFFLPARA	List parameters off-line
ONLMISS	List mission on-line
ONLPARA	List parameters on-line
PERFECT	Mainline simulation
PREPRO	Preprocessor
RFPARA	Read parameter file
SIMU	Simulation and sleep calculations
WFPARA	Write parameter file

(b) General Flow Chart of Simulation Subroutine




CONSIDER NEXT MISSION
PLATOON ACTION
FROM
PAGE 1
a
NEXT DAY
D = D+1
b
UNIT
NO.
CHANGE
?
YES
SET NEW VALUE OF U.
RESET STRESS FACTOR
STRESSF (T,U) = 0
U = U+1
NO
COMBAT
TYPE NO.
CHANGE
?
NO
YES
SET NEW VALUE OF T
TYPE OF UNIT
RESET STRESS FACTOR
STRESSF (T,U) = 1
SLEEP
ACTION?
PA(D,T,U,S) = 0?
SLEEP
DEPRIVATION
>16
NO
c
TO PAGE 3
YES
d
CALCULATE SLEEP DEPRIVATION, RECOVERY,
PERCENT RECOVERY TIME, PERCENT NORMAL
FUNCTION RECOVERED EFFECT, STRESS TIME
AND CURRENT EFFECTIVENESS
RECOVH = 1/.03494 ln SLPDEP (7,U)/4.6949
PERREC = DUR (D,T,U,S) / RECOVH ≤ 1
PERNORM = (PRREC)^0.5
EFFECT = (PERNORM) [SLPDEP (T,U)]
STIME (T,U) = STIME (T,U) – EFFECT
SLPDEP (T,U) = [SLPDEP (T,U)] [1–PERREC] ≥0
IF STIME (T,U), SD (T,U) = SD (T,U) + 1
STIME (T,U) = 24 + STIME (U,T)
ECUR(F,T,D,U) = ECUR (F,T,D,U) + E4 (D,PA,F,T) [EFFECT]
IF EFFECT – CTIME (U,T) <0
ECUR (F,D,T,U) = ECUR (F,D,T,U) + E4 (D,PA,F,T)[CTIME]
+ E4 (SDAY,PA,F,T) [EFFECT – CTIME], OTHERWISE
e


FROM PAGE 2
c
UPDATE VALUE OF CURRENT TIME
CTIME = CTIME + DUR (D,T,U,S)
CALCULATE STRESS FACTOR AND ADDITIVE, STA
(SEE NOTE A)
UPDATE VALUE OF STRESS TIME, STRESS DAY, CURRENT EFFECTIVENESS
STIME (T,U) = STIME (T,U) + STA + DUR (T,U)
IF STIME (T,U) ⩾ 24 STIME (T,U) = STIME (T,U) − 24
SD = SD + 1
(SEE NOTE B)
CALCULATE CURRENT VALUE OF SLEEP DEPRIVATION FOR THE COMBAT UNIT
SLPDEP (T,U) = SLPDEP (T,U) + DUR (D,T,U,S)
e
DETERMINE WHETHER OR NOT A REPLACEMENT IS SPECIFIED FOR THIS UNIT, TYPE, DAY AND TIME
IF RT (R) = T & RU (R) = U &
RD (R) = D & RH (R) ⩽ CTIME
THEN: R = R+1 (NEXT REINFORCEMENT DATA SET)
STIME (T,U) = 0
SD (T,U) = 1
} RESETS
ECUR (F,D,T,U) = 1 FOR ALL F
SLPDEP (T,U) = 2HSLS/3 (1 + RN)
RN = RANDOM NO. (0–1)
END OF DAY CTIME = 24 END OF DATA ?
YES
LAST DAY ? D = 5
YES
NO
NO
f
TO OUTPUT
a
b


f
OUT(2)
NO
YES
LIST END-OF-DAY EFFECTIVENESS INDEX
ECUR (F,D,T,U) = E5
AVERAGE END-OF-DAY EFFECTIVENESS VALUES OVER ALL UNITS OF A GIVEN TYPE
FOR ALL VALUES OF D,F,T:
E6 (D,F,T) = Σ (U=1 to MU) ECUR (F,D,T,U) / MU
OUT (2)
YES
NO
LIST AVERAGE END-OF-DAY EFFECTIVENESS VALUES BY TYPE
AVERAGE END-OF-DAY EFFECTIVENESS VALUES OVER ALL COMBAT UNIT TYPES
FOR ALL VALUES OF D,F:
E7 (D,F) = Σ (T=1 to MT) E6 (D,F,T) / MT
AVERAGE END-OF-DAY EFFECTIVENESS VALUES OVER ALL FACTORS
E8 (D,T) = Σ (F=1 to MF) E6 (D,F,T) / MF
TO OUTPUT LISTING MODULE

Note A

$$H = CTIME - \frac{DUR\ (U, T)}{2} + HR$$

$$OLDSTRESSF = STRESSF\ (U, T)$$

$$For\ F = 1, \ldots 5:\ VUL(F) = 5[1 - ECUR(F, D, T, U)]$$

$$For\ F = 1, \ldots 5:\ STRESS(F) = EFM \cdot EFP \cdot LIGHT(F) \cdot UPF(T) \cdot EFTA(D) \cdot VUL(F)$$

$$STRESS(T, U) = \sum_{F=1}^{5} STRESS(F) \cdot FTYPE(F, T)$$

$$HRI1 = \frac{24}{25}\ (OLDSTRESS)$$

$$HRI2 = \frac{24}{25}\ [STRESS(T, U)]$$

$$STA = HRI2 - HRI1$$

Note B

$$STIME(T, U) = STIME(T, U) + STA + DUR\ (D, T, U, S)$$

$$if\ STIME(T, U) \geq 24\ \ STIME(T, U) = STIME(T, U) - 24$$

$$SD(T, U) = SD(T, U) + 1$$

$$SDAV = SD(T, U)$$

For F = 1, ...5:

$$ECUR(F, D, T, U) = ECUR(F, D, T, U) - E4\ (D, PA, F, T)[DUR(D, T, U, S)]$$

$$if\ CTIME + STA < 24\ (stress\ for\ D)$$

$$ECUR(F, D, T, U) = ECUR(F, D, T, U) - E4(D, PA, F, T)[STA]$$

$$otherwise:\ (stress\ for\ D + 1)$$

$$ECUR(F, D, T, U) = ECUR(F, D, T, U) - E4(D, PA, F, T)[24 - CTIME]$$

$$- E4\ (SDAY, PA, F, T,)[STIME(T, U)]$$

$$If\ HRI1 = HRI2 = 24\ and\ if\ STRESS(T, U) > 25\ then$$

$$ECUR(F, D, T, U) = ECUR(F, D, T, U) - E4(SDAY, PA, F, T)$$

$$\left[\frac{STRESS}{25}\right]\left[\frac{DUR(D, T, U, S)}{24}\right]$$

APPENDIX D

Projected Effectiveness
E (D, PA, DP, CT) for Critical Combat Tasks

The full scenario from which the critical tasks were drawn is found in Siegel, et al., (1979).

Mechanized Infantry: Gunner/Carrier Team Leader
(Duty Position 1, i.e., DP = 1)

		Critical Task No.																
	Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Platoon Action$_1$ (PA=1)[1]	1	61	62	67	78	100	57	78	92	73	71	36	51	57	41	100	100	92
	2	37	39	46	61	100	32	61	84	53	51	13	27	32	17	100	100	84
	3	23	24	31	48	100	18	48	78	38	36	05	14	18	07	100	100	78
	4	14	15	21	37	100	10	37	71	28	26	02	07	10	03	100	100	71
	5	08	09	14	29	100	06	29	65	20	18	01	04	06	01	100	100	65
Platoon Action$_2$ (PA=2)[2]	1	61	67	100	100	100	92	84	92	73	85	46	78	85	57	73	55	100
	2	37	46	100	100	100	84	71	84	53	73	21	61	73	32	53	30	100
	3	23	31	100	100	100	78	59	78	38	62	10	48	62	18	38	17	100
	4	14	21	100	100	100	71	50	71	28	53	04	37	53	10	28	09	100
	5	08	14	100	100	100	65	42	65	20	45	02	29	45	06	20	05	100
Platoon Action$_3$ (PA=3)[3]	1	100	100	100	100	100	57	78	92	73	100	100	100	100	100	100	100	100
	2	100	100	100	100	100	32	61	84	53	100	100	100	100	100	100	100	100
	3	100	100	100	100	100	18	48	78	38	100	100	100	100	100	100	100	100
	4	100	100	100	100	100	10	37	71	28	100	100	100	100	100	100	100	100
	5	100	100	100	100	100	06	29	65	20	100	100	100	100	100	100	100	100

NOTE: A value of 100 after the second day implies that only NOMINAL DEGRADATION will occur after that day.

A value of 00 is to be interpreted as E<1 (i.e., very low).

Mechanized Infantry: Maneuver Team Member
(DP = 2)

		Critical Task No.														
	Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Platoon Action$_1$	1	78	100	78	100	100	100	100	78	100	100	100	100	57	100	100
	2	61	100	61	100	100	100	100	61	100	100	100	100	32	100	100
	3	48	100	48	100	100	100	100	48	100	100	100	100	18	100	100
	4	37	100	37	100	100	100	100	37	100	100	100	100	10	100	100
	5	29	100	29	100	100	100	100	29	100	100	100	100	06	100	100
Platoon Action$_2$	1	85	73	78	85	67	100	100	86	62	100	74	100	100	100	100
	2	73	53	61	73	46	100	100	74	39	100	54	100	100	100	100
	3	62	38	48	62	31	100	100	63	24	100	40	100	100	100	100
	4	53	28	37	53	21	100	100	54	15	100	29	100	100	100	100
	5	45	20	29	45	14	100	100	47	09	100	22	100	100	100	100
Platoon Action$_3$	1	100	56	78	65	100	85	67	60	100	100	100	73	100	85	62
	2	100	32	61	43	100	73	46	37	100	100	100	53	100	73	38
	3	100	18	48	28	100	62	31	22	100	100	100	38	100	62	23
	4	100	10	37	18	100	53	21	13	100	100	100	28	100	53	14
	5	100	06	29	12	100	45	14	08	100	100	100	20	100	45	09

Mechanized Infantry: Squad Leader
(DP = 3)

		Critical Task No.																
	Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Platoon Action 1	1	100	100	100	100	100	100	26	61	31	51	62	26	71	100	100	100	100
	2	100	100	100	100	100	100	07	37	10	26	39	07	51	100	100	100	100
	3	100	100	100	100	100	100	02	23	03	13	24	02	36	100	100	100	100
	4	100	100	100	100	100	100	00	14	01	07	15	00	26	100	100	100	100
	5	100	100	100	100	100	100	00	08	00	03	09	00	18	100	100	100	100
Platoon Action 2	1	100	100	100	67	73	85	67	61	46	67	78	31	78	66	100	100	100
	2	100	100	100	44	53	73	46	37	22	46	61	10	61	44	100	100	100
	3	100	100	100	29	38	62	31	23	10	31	48	03	48	29	100	100	100
	4	100	100	100	20	28	53	21	14	05	21	37	01	37	19	100	100	100
	5	100	100	100	13	20	45	14	08	02	14	29	00	**29**	13	100	100	100
Platoon Action 3	1	61	78	67	45	46	100	26	46	41	92	52	26	71	100	41	73	51
	2	37	61	45	21	22	100	07	21	17	84	27	07	51	100	17	53	26
	3	23	48	30	09	10	100	02	10	07	78	14	02	36	100	07	38	13
	4	14	37	20	04	05	100	00	04	03	71	07	00	26	100	03	28	07
	5	08	29	13	02	02	100	00	02	01	65	04	00	18	100	01	20	03

Mechanized Infantry: Platoon Leader
(DP = 4)

		Critical Task No.																
	Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Platoon Action$_1$	1	100	100	100	100	100	100	56	67	100	84	100	67	92	100	100	100	84
	2	100	100	100	100	100	100	32	46	100	71	100	45	84	100	100	100	71
	3	100	100	100	100	100	100	18	31	100	59	100	30	78	100	100	100	59
	4	100	100	100	100	100	100	10	21	100	50	100	20	71	100	100	100	50
	5	100	100	100	100	100	100	06	14	100	42	100	13	65	100	100	100	42
Platoon Action$_2$	1	67	85	100	78	47	100	61	78	100	92	78	100	100	100	78	100	100
	2	46	73	100	61	22	100	37	61	100	84	61	100	100	100	61	100	100
	3	31	62	100	48	10	100	23	48	100	78	48	100	100	100	48	100	100
	4	21	53	100	37	05	100	14	37	100	71	37	100	100	100	37	100	100
	5	14	45	100	29	02	100	08	29	100	65	29	100	100	100	29	100	100
Platoon Action$_3$	1	67	73	92	71	32	92	49	56	71	78	36	56	92	42	56	91	77
	2	46	53	84	51	10	84	25	32	51	61	13	31	84	18	31	82	59
	3	31	38	78	36	03	78	12	18	36	48	05	17	78	07	17	75	45
	4	21	28	71	26	01	71	06	10	26	37	02	10	71	03	10	68	35
	5	14	20	65	18	00	65	03	06	18	29	01	05	65	01	05	61	27

Mechanized Infantry: Platoon Leader (cont.)
(DP = 4)

		Critical Task No.									
	Day	18	19	20	21	22	23	24	25	26	27
Platoon Action$_1$	1	100	52	42	100	100	100	100	100	100	100
	2	100	27	18	100	100	100	100	100	100	100
	3	100	14	07	100	100	100	100	100	100	100
	4	100	07	03	100	100	100	100	100	100	100
	5	100	04	01	100	100	100	100	100	100	100
Platoon Action$_2$	1	100	100	67	100	100	100	100	100	100	72
	2	100	100	46	100	100	100	100	100	100	52
	3	100	100	31	100	100	100	100	100	100	37
	4	100	100	21	100	100	100	100	100	100	27
	5	100	100	14	100	100	100	100	100	100	19
Platoon Action$_3$	1	92	41	36	92	57	61	41	60	78	56
	2	84	17	13	84	32	37	17	37	61	31
	3	78	07	05	78	18	23	07	22	48	17
	4	71	03	02	71	10	14	03	13	37	10
	5	65	01	01	65	06	08	01	08	29	05

Armor: Tank Platoon Leader
(DP = 8)

		Critical Task No.																
	Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Platoon Action$_1$	1	100	100	71	65	71	71	71	92	100	100	100	71	71	56	67	66	78
	2	100	100	51	43	51	51	51	84	100	100	100	51	51	31	45	44	61
	3	100	100	36	28	36	36	36	78	100	100	100	36	36	17	30	29	48
	4	100	100	26	18	26	26	26	71	100	100	100	26	26	10	20	19	37
	5	100	100	18	12	18	18	18	65	100	100	100	18	18	05	13	13	29
Platoon Action$_2$	1	100	100	84	100	100	84	100	100	100	92	100	100	100	56	92	100	84
	2	100	100	71	100	100	71	100	100	100	84	100	100	100	31	84	100	71
	3	100	100	59	100	100	59	100	100	100	78	100	100	100	17	78	100	59
	4	100	100	50	100	100	50	100	100	100	71	100	100	100	10	71	100	50
	5	100	100	42	100	100	42	100	100	100	65	100	100	100	05	65	100	42
Platoon Action$_3$	1	78	73	78	78	78	78	78	100	100	100	100	100	100	100	100	100	100
	2	61	53	61	61	61	61	61	100	100	100	100	100	100	100	100	100	100
	3	48	38	48	48	48	48	48	100	100	100	100	100	100	100	100	100	100
	4	37	28	37	37	37	37	37	100	100	100	100	100	100	100	100	100	100
	5	29	20	29	29	29	29	29	100	100	100	100	100	100	100	100	100	100

Armor: Tank Platoon Leader (cont.)
(DP = 8)

		Critical Task No.								
	Day	18	19	20	21	22	23	24	25	26
Platoon Action$_1$	1	61	92	100	84	66	84	51	71	85
	2	37	84	100	71	44	71	27	51	73
	3	23	78	100	59	29	59	14	36	62
	4	14	71	100	50	19	50	07	26	53
	5	08	65	100	42	13	42	04	18	45
Platoon Action$_2$	1	92	100	100	100	100	100	84	100	100
	2	84	100	100	100	100	100	71	100	100
	3	78	100	100	100	100	100	59	100	100
	4	71	100	100	100	100	100	50	100	100
	5	65	100	100	100	100	100	42	100	100
Platoon Action$_3$	1	100	100	100	100	66	73	51	71	100
	2	100	100	100	100	44	53	27	51	100
	3	100	100	100	100	29	38	14	36	100
	4	100	100	100	100	19	28	07	26	100
	5	100	100	100	100	13	20	04	18	100

Armor: Tank Commander
(DP = 5)

	Day	Critical Task No. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Platoon Action$_1$	1	92	92	84	77	100	78	72	85	56	92	92	84	66	73	92
	2	84	84	71	59	100	61	52	73	32	84	84	71	44	53	84
	3	78	78	59	45	100	48	37	62	18	78	78	59	29	38	78
	4	71	71	50	35	100	37	27	53	10	71	71	50	19	28	71
	5	65	65	42	27	100	29	19	45	06	65	65	42	13	20	65
Platoon Action$_2$	1	100	100	92	100	100	84	100	100	84	100	100	100	100	100	100
	2	100	100	84	100	100	71	100	100	71	100	100	100	100	100	100
	3	100	100	78	100	100	59	100	100	59	100	100	100	100	100	100
	4	100	100	71	100	100	50	100	100	50	100	100	100	100	100	100
	5	100	100	65	100	100	42	100	100	42	100	100	100	100	100	100
Platoon Action$_3$	1	100	92	100	100	100	100	100	100	100	100	100	100	66	73	100
	2	100	84	100	100	100	100	100	100	100	100	100	100	44	53	100
	3	100	78	100	100	100	100	100	100	100	100	100	100	29	38	100
	4	100	71	100	100	100	100	100	100	100	100	100	100	19	28	100
	5	100	65	100	100	100	100	100	100	100	100	100	100	13	20	100

Armor: Tank Gunner
(DP = 6)

		Critical Task No.				
	Day	1	2	3	4	5
Platoon Action$_1$	1	100	100	100	100	100
	2	100	100	100	100	100
	3	100	100	100	100	100
	4	100	100	100	100	100
	5	100	100	100	100	100
Platoon Action$_2$	1	100	100	100	100	100
	2	100	100	100	100	100
	3	100	100	100	100	100
	4	100	100	100	100	100
	5	100	100	100	100	100
Platoon Action$_3$	1	84	84	100	100	84
	2	71	71	100	100	71
	3	59	59	100	100	59
	4	50	50	100	100	50
	5	42	42	100	100	42

Armor: Tank Loader
(DP = 7)

		Critical Task No.											
	Day	1	2	3	4	5	6	7	8	9	10	11	12
Platoon Action$_1$	1	100	100	100	100	100	100	100	100	100	92	92	100
	2	100	100	100	100	100	100	100	100	100	84	84	100
	3	100	100	100	100	100	100	100	100	100	78	78	100
	4	100	100	100	100	100	100	100	100	100	71	71	100
	5	100	100	100	100	100	100	100	100	100	65	65	100
Platoon Action$_2$	1	100	100	100	100	100	100	100	100	100	100	100	100
	2	100	100	100	100	100	100	100	100	100	100	100	100
	3	100	100	100	100	100	100	100	100	100	100	100	100
	4	100	100	100	100	100	100	100	100	100	100	100	100
	5	100	100	100	100	100	100	100	100	100	100	100	100
Platoon Action$_3$	1	100	100	100	100	100	100	100	100	100	100	100	100
	2	100	100	100	100	100	100	100	100	100	100	100	100
	3	100	100	100	100	100	100	100	100	100	100	100	100
	4	100	100	100	100	100	100	100	100	100	100	100	100
	5	100	100	100	100	100	100	100	100	100	100	100	100

FIST: Chief
(DP 11)

		Critical Task No.																
	Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Platoon Action$_1$	1	92	85	85	85	100	100	100	78	84	47	56	85	71	47	57	51	100
	2	84	73	73	73	100	100	100	61	71	22	31	73	51	22	32	27	100
	3	78	62	62	62	100	100	100	48	59	10	17	62	36	10	18	14	100
	4	71	53	53	53	100	100	100	37	50	05	10	53	26	05	10	07	100
	5	65	45	45	45	100	100	100	29	42	02	05	45	18	02	06	04	100
Platoon Action$_2$	1	100	100	100	100	92	84	78	85	92	56	74	85	92	56	100	100	100
	2	100	100	100	100	84	71	61	73	84	32	54	73	84	32	100	100	100
	3	100	100	100	100	78	59	48	62	78	18	40	62	78	18	100	100	100
	4	100	100	100	100	71	50	37	53	71	10	29	53	71	10	100	100	100
	5	100	100	100	100	65	42	29	45	65	06	22	45	65	06	100	100	100
Platoon Action$_2$	1	92	85	100	100	65	100	78	78	84	47	56	85	100	47	57	51	85
	2	84	73	100	100	43	100	61	61	71	22	31	73	100	22	32	27	73
	3	78	62	100	100	28	100	48	48	59	10	17	62	100	10	18	14	62
	4	71	53	100	100	18	100	37	37	50	05	10	53	100	05	10	07	53
	5	65	45	100	100	12	100	29	29	42	02	05	45	100	02	06	04	45

FIST: Chief (cont.)
(DP = 11)

		Critical Task No.											
	Day	18	19	20	21	22	23	24	25	26	27	28	29
Platoon Action$_1$	1	100	100	47	57	57	100	100	60	32	74	100	92
	2	100	100	22	32	32	100	100	37	10	54	100	84
	3	100	100	10	18	18	100	100	22	03	40	100	78
	4	100	100	05	10	10	100	100	13	01	29	100	71
	5	100	100	02	06	06	100	100	08	00	22	100	65
Platoon Action$_2$	1	100	100	51	100	57	100	67	60	32	100	100	92
	2	100	100	27	100	32	100	45	37	10	100	100	84
	3	100	100	14	100	18	100	30	22	03	100	100	78
	4	100	100	07	100	10	100	20	13	01	100	100	71
	5	100	100	04	100	06	100	13	08	00	100	100	65
Platoon Action$_3$	1	92	71	47	100	52	47	100	60	32	100	100	92
	2	84	51	22	100	27	22	100	37	10	100	100	84
	3	78	36	10	100	14	10	100	22	03	100	100	78
	4	71	26	05	100	07	05	100	13	01	100	100	71
	5	65	18	02	100	04	02	100	08	00	100	100	65

FIST: Forward Observer
(DP = 9)

		Critical Task No.																
	Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Platoon Action$_1$	1	92	92	85	85	100	65	100	78	72	61	78	78	56	85	100	47	100
	2	84	84	73	73	100	43	100	61	52	37	61	61	31	73	100	22	100
	3	78	78	62	62	100	28	100	48	37	23	48	48	17	62	100	10	100
	4	71	71	53	53	100	18	100	37	27	14	37	37	10	53	100	05	100
	5	65	65	45	45	100	12	100	29	19	08	29	29	05	45	100	02	100
Platoon Action$_2$	1	100	92	100	85	100	78	78	85	85	78	78	78	74	85	71	56	100
	2	100	84	100	73	100	61	61	73	73	61	61	61	54	73	51	32	100
	3	100	78	100	62	100	48	48	62	62	48	48	48	40	62	36	18	100
	4	100	71	100	53	100	37	37	53	53	37	37	37	29	53	26	10	100
	5	100	65	100	45	100	29	29	45	45	29	29	29	22	45	18	06	100
Platoon Action$_3$	1	92	92	100	85	100	65	78	78	72	61	78	78	56	85	71	47	57
	2	84	84	100	73	100	43	61	61	52	37	61	61	31	73	51	22	32
	3	78	78	100	62	100	28	48	48	37	23	48	48	17	62	36	10	18
	4	71	71	100	53	100	18	37	37	27	14	37	37	10	53	26	05	10
	5	65	65	100	45	100	12	29	29	19	08	29	29	05	45	18	02	06

FIST: Forward Observer (cont.)
(DP = 11)

		Critical Task No.									
	Day	18	19	20	21	22	23	24	25	26	27
Platoon Action$_1$	1	47	47	62	52	100	100	60	32	74	92
	2	22	22	38	27	100	100	37	10	54	84
	3	10	10	23	14	100	100	22	03	40	78
	4	05	05	14	07	100	100	13	01	29	71
	5	02	02	09	04	100	100	08	00	22	65
Platoon Action$_2$	1	100	51	100	57	100	67	60	32	100	92
	2	100	27	100	32	100	45	37	10	100	84
	3	100	14	100	18	100	30	22	03	100	78
	4	100	07	100	10	100	20	13	01	100	71
	5	100	04	100	06	100	13	08	00	100	65
Platoon Action$_3$	1	47	47	62	52	47	100	60	32	100	92
	2	22	22	38	27	22	100	37	10	100	84
	3	10	10	23	14	10	100	22	03	100	78
	4	05	05	14	07	05	100	13	01	100	71
	5	02	02	09	04	02	100	08	00	100	65

FIST: 1. Fire Support NCO (DP = 12)

	Day	Critical Task No. 1	Critical Task No. 2
Platoon Action 1	1	100	100
	2	100	100
	3	100	100
	4	100	100
	5	100	100
Platoon Action 2	1	100	100
	2	100	100
	3	100	100
	4	100	100
	5	100	100
Platoon Action 3	1	92	92
	2	84	84
	3	78	78
	4	71	71
	5	65	65

2. Radio Telephone Operator (DP = 10)

Critical Task No. 1
100
100
100
100
100
92
84
78
71
65
92
84
78
71
65

Artillery: Battery Executive Officer
(DP=16)

		Critical Task No.					
		1	2	3	4	5	6
Platoon Action$_1$	1	92	92	100	92	100	100
	2	84	84	100	84	100	100
	3	78	78	100	78	100	100
	4	71	71	100	71	100	100
	5	65	65	100	65	100	100
Platoon Action$_2$	1	92	72	84	41	92	92
	2	84	52	71	17	84	84
	3	78	37	59	07	78	78
	4	71	27	50	03	71	71
	5	65	19	42	01	65	65
Platoon Action$_3$	1	85	72	78	37	87	73
	2	73	52	61	14	76	53
	3	62	37	48	05	66	38
	4	53	27	37	02	57	28
	5	45	19	29	01	50	20

Artillery: Howitzer Section Chief
(DP = 13)

Critical Task No.

	Day	1	2	3	4	5	6	7	8	9	10	11
Low	1	100	100	92	85	92	100	100	100	78	84	100
	2	100	100	84	73	84	100	100	100	61	71	100
	3	100	100	78	62	78	100	100	100	48	59	100
	4	100	100	71	53	71	100	100	100	37	50	100
	5	100	100	65	45	65	100	100	100	29	42	100
Medium	1	100	85	61	73	84	100	100	100	73	67	73
	2	100	73	37	53	71	100	100	100	53	45	53
	3	100	62	23	38	59	100	100	100	38	30	38
	4	100	53	14	28	50	100	100	100	28	20	28
	5	100	45	08	20	42	100	100	100	20	13	20
Heavy	1	92	85	61	67	78	92	92	92	73	67	67
	2	84	73	37	45	61	84	84	84	53	45	46
	3	78	62	23	30	48	78	78	78	38	30	31
	4	71	53	14	20	37	71	71	71	28	20	21
	5	65	45	08	13	29	65	65	65	20	13	14

Artillery: 155mm Gunner
(DI = 14)

Critical Task No.

	Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Platoon Action (Low) [1]	1	92	100	92	100	92	92	92	92	100	100	92	100	85	84	85	85	92
	2	84	100	84	100	84	84	84	84	100	100	84	100	73	71	73	73	84
	3	78	100	78	100	78	78	78	78	100	100	78	100	62	59	62	62	78
	4	71	100	71	100	71	71	71	71	100	100	71	100	53	50	53	53	71
	5	65	100	65	100	65	65	65	65	100	100	65	100	45	42	45	45	65
Platoon Action (Medium) [2]	1	72	85	67	85	78	78	84	78	78	84	78	92	72	84	73	73	67
	2	52	73	45	73	61	61	71	61	61	71	61	84	52	71	53	53	45
	3	37	62	30	62	48	48	59	48	48	59	48	78	37	59	38	38	30
	4	27	53	20	53	37	37	50	37	37	50	37	71	27	50	28	28	20
	5	19	45	13	45	29	29	42	29	29	42	29	65	19	42	20	20	13
Platoon Action (Heavy) [3]	1	72	85	67	85	78	78	84	78	78	84	78	84	72	84	73	73	67
	2	52	73	45	73	61	61	71	61	61	71	61	71	52	71	53	53	45
	3	37	62	30	62	48	48	59	48	48	59	48	59	37	59	38	38	30
	4	27	53	20	53	37	37	50	37	37	50	37	50	27	50	28	28	20
	5	19	45	13	45	29	29	42	29	29	42	29	42	19	42	20	20	13

Artillery: 155mm Crew Member
(DP = 15)

		Critical Task No.													
	Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Low	1	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	2	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	3	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	4	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	5	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Medium	1	100	100	100	100	100	85	100	92	85	100	100	100	92	78
	2	100	100	100	100	100	73	100	84	73	100	100	100	84	61
	3	100	100	100	100	100	62	100	78	62	100	100	100	78	48
	4	100	100	100	100	100	53	100	71	53	100	100	100	71	37
	5	100	100	100	100	100	45	100	65	45	100	100	100	65	29
Heavy	1	100	100	100	100	100	85	92	92	85	100	92	100	92	78
	2	100	100	100	100	100	73	84	84	73	100	84	100	84	61
	3	100	100	100	100	100	62	78	78	62	100	78	100	78	48
	4	100	100	100	100	100	53	71	71	53	100	71	100	71	37
	5	100	100	100	100	100	45	65	65	45	100	65	100	65	29

APPENDIX E

Factor Table Input

APPENDIX E

FACTOR TABLE INPUT
FAC(CT, DP)

Critical Task No. (CT)	Duty Position (DP)															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	2	2	2	4	3	4	2	3	3	3	2	3	4	5	3	1
2	2	2	1	2	3	4	2	3	3	–	2	3	2	5	3	1
3	2	2	2	3	5	3	2	5	1	–	2	–	5	5	3	1
4	2	1	4	4	5	2	2	5	1	–	2	–	4	5	5	1
5	2	1	1	1	1	2	5	5	1	–	5	–	4	5	3	2
6	3	4	1	3	3	2	5	5	5	–	2	–	4	5	1	1
7	5	2	1	1	4	–	5	5	4	–	4	–	1	5	3	–
8	3	1	1	4	3	–	2	3	5	–	5	–	1	5	2	–
9	2	2	1	4	5	–	2	3	5	–	5	–	1	5	2	–
10	1	5	3	1	4	–	1	5	1	–	1	–	5	5	5	–
11	2	2	1	2	3	–	2	5	4	–	1	–	1	5	5	–
12	1	2	1	1	2	–	2	5	4	–	5	–	–	5	3	–
13	4	2	1	3	5	–	–	5	1	–	1	–	–	5	5	–
14	4	2	1	1	3	–	–	1	2	–	1	–	–	5	5	–
15	5	2	1	1	3	–	–	4	1	–	1	–	–	2	–	–
16	4	–	2	3	–	–	–	5	1	–	1	–	–	2	–	–
17	3	–	1	4	–	–	–	5	1	–	2	–	–	5	–	–
18	–	–	–	3	–	–	–	1	1	–	2	–	–	–	–	–
19	–	–	–	1	–	–	–	4	1	–	2	–	–	–	–	–
20	–	–	–	1	–	–	–	2	1	–	1	–	–	–	–	–
21	–	–	–	3	–	–	–	2	1	–	1	–	–	–	–	–
22	–	–	–	1	–	–	–	5	1	–	1	–	–	–	–	–
23	–	–	–	1	–	–	–	1	1	–	1	–	–	–	–	–
24	–	–	–	1	–	–	–	5	1	–	2	–	–	–	–	–
25	–	–	–	1	–	–	–	1	1	–	1	–	–	–	–	–
26	–	–	–	3	–	–	–	5	1	–	1	–	–	–	–	–
27	–	–	–	1	–	–	–	–	3	–	1	–	–	–	–	–
28	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–
29	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–

APPENDIX F

List of PERFECT Model Variables

Variable Name (FORTRAN)	Definition; explanation
CTIME	- Current time of day (hours)
E2 (D, PA, DP, F)	- End of day effectiveness matrix summarized over all critical tasks
E3 (D, PA, F, T)	- End of day effectiveness matrix averaged over all duty positions
E4 (D, PA, F, T)	- Effectiveness decrement per hour each day
E6 (D, F, T)	- End of day effectiveness values averaged over all units of each type
E7 (D, F)	- End of day effectiveness values averaged over all units and all types
E8 (D, T)	- End of day effectiveness values averaged over all units and all factors
ECUR (F, D, T, U)	- Current value of effectiveness for day (D), factor (F), unit type (T), and number (U)
EFFECT	- Number of stress time decrease hours as a result of this sleep
H	- Time of midpoint of the platoon action (hours)
HRI 1, HRI 2	- Hour increment, amount of time corresponding to the current stress condition (hours) HRI 1 - prior for this U, T HRI 2 - current for this U, T
LIGHTF (D)	- Light factor dependent upon LIGHT (L, H)
PERNORM	- Percentage of normal function received by current sleep number
PERREC	- Percentage recovery time resulting from current sleep
RECOVH	- Hours sleep required for 100% recovery from sleep deprivation
RN	- Pseudo random number, equiprobable in 0 - 1 range
SD (T, U)	- Day number corresponding to current stress condition
SLPDEP (T, U)	- Number of hours since last sleep (sleep deprivation)
STA	- stress additive = HRI 2 — HRI 1 = increase in time stress since last platoon action

STIME(T, U)	-	Stress time -- time of day in SD corresponding to current stress condition
STRESS(T, U)	-	Current value of stress
STRESSF(T, U)	-	Current value of stress factor
VUL(F)	-	Vulnerability = 1 - Effectiveness

Parameter Name (FORTRAN)		Definition; explanation
EFM	-	Enemy/friendly material strength ratio
EFP	-	Enemy/friendly personnel strength ratio
EFTA(D)	-	Enemy/friendly terrain advantage ratio for each day
HR	-	Time of day battle starts, an hour number
HSLS	-	Hours since last sleep at start of battle
L(D)	-	Light level profile for each day
RD(R)	-	Unit replacement data -- day number of battle
RH(R)	-	Unit replacement data -- time of day
RT(R)	-	Unit replacement data -- combat unit type
RU(R)	-	Unit replacement -- combat unit number
UPF(T)	-	Unit proficiency factor, proficiency of troops in each unit

Subscript		Definition; explanation
CT	-	Critical task number
D	-	Day number
DP	-	Duty position number
F	-	Factor
H	-	Hour number
L	-	Light level profile number
PA	-	Platoon action number
R	-	Replacement number
T	-	Type of combat unit
U	-	Combat unit number
Data Arrays	-	See Table B. 2

APPENDIX G

Model Implementation on the U 1100 System

The model, described previously, is also hosted on the UNIVAC 1100 system, ARRADCOM, Aberdeen Proving Ground. At the ARRADCOM the model was compiled on the FORTRAN (ASCII) compiler. This appendix presents specific instructions for exercising the PERFECT model on that system. As such, the Appendix supercedes Step F and Step G (pages 21, 23) of this manual and parts of Step K when the ARRADCOM's UNIVAC 1100 system is used.

Step F. (U 1100) Terminal Log-On

1. Dial the phone number of the computer center (for remote operation).
2. Turn the modem or coupler "ON" (if it is a device separate from the terminal).
3. Upon hearing a high pitched sound in the phone's receiver, place the phone's handset into the modem (coupler). Be sure the mouthpiece is placed in the cord end receptacle.
4. Turn the terminal's mode switch to the "LINE" ("REMOTE") position to indicate that interactive (not local) operations are to follow.
5. Enter appropriate Site ID and depress RETURN (in the following the ↵ sign indicates the necessity to depress the RETURN key).
6. Enter "PASSWORD."↵
   After entering the PASSWORD, the system will respond with a " > " symbol. This symbol indicates that the system is soliciting a command.
7. Enter: @RUN user's name, 855A1F, PERFECT↵
   @ASG, A PERFECT.↵
   The ASG statement prepares the program for use. The system will respond with, READY or a FACILITY WARNING. Either of these indicates that the next command can be entered:
   @ADD PERFECT.START↵
   The add statement initializes the data files and executes the model. It will be followed by a series of READY or FACILITY WARNING responses followed be the first statements of the model. (Following this, PERFECT runs as described in the body of this Manual.)

Step G. (U 1100) Other Terminal Operations

This section describes some utility operations which a terminal operator may need before, during, and after simulation model runs. Each is independent of the other and these procedures may be performed in any order.

1. To terminate terminal operations:

   a. Enter:
   @FIN↵
   This action will be followed by a cost itemization for the session.

   b. Enter:
   @@TERM↵
   This action will disconnect the line.

2. To correct operator typing errors:

   a. To delete a line entered prior to its transmission to the computer; hold down the "CONTROL" key and simultaneously press the "X" key.

   b. To delete the most recent character (TTY only) entered prior to its transmission, hold down the "CONTROL" key and simultaneously press the "Z" key.

3. To terminate a terminal print before its completion or to signal completion of all runs desired for a single session:

   a. Press the "BREAK" key.

   b. Enter:
   @@X TIO↵
   The computer will respond with an EXECUTION TERMUNATED and the solicitation mark. (>)

4. To list the basic files stored as part of the program:

   a. Obtain the computer solicitation " >."

   b. For a data file listing select the desired file and enter:
   @DATA, L File name.↵
   @END
   The data files that can be examined are:

Content	File Name
Effectiveness = E1	EFF1.
Factors	FACTORS.
Manning	MEN.
Mission	MISSION.
Effectiveness Reduction = E4	E4.
Parameters	PARAMET.

Note: Each file name must end with a period, e.g., @DATA, L EFF1.↵

c. To have a subroutine or element listed enter:
@PRT PERFECT. subroutine or element name↵
e.g.
@PRT PERFECT. SIMU↵

Note: Each subroutine or element name does not end with a period, only the file name, PERFECT. ends with a period.

Step K. (U 1100)

For U 1100 exercise of the model, the following replaces Step K: 12, 13; p. 31.

1. After a terminal session (each run), the user can request a printout of the intermediate arrays including preprocessing.
   a. After " >" enter:
   @ADD PERFECT. NOSEDATA↵
   b. The computer will respond: SENT BY name.
   c. The intermediate data file will be printed out at Aberdeen and sent to the user.
2. Alternately, these intermediate results may be noted on the terminal.
   a. Enter:
   @DATA, L NOSEDATA.↵
   @END↵
   b. The date will be printed at the remote terminal.

New Changes

The U 1100 implementation is essentially the same as the prior version of PERFECT except for the addition of a new function and new elements. The new function, the PERFECT.KOMPCH function, replaces the KOMPCH subroutine which is a system feature specific to the Honeywell System.

The new elements are:

1. PERFECT.START
2. PERFECT.DATA
3. PERFECT.NOSEDATA

The PERFECT.START is used to start PERFECT. and is made up of assignment and execution statements. The PERFECT.START element contains the following:

```
@ASG, A          EFF1.
@ASG, A          FACTOR1.
@ASG, A          MEN.
@ASG, A          MISSION.
@ASG, A          PARAMET.
@ASG, A          E4.
@ASG, A          NOSEDATA.
@XQT             PERFECT.
```

The first six of these concern the assignment of input data files. The sixth assigns the detailed output file, while the final statement executes the program. The content of each data file is:

File	Content	Comment
EFF1.	Contain effectiveness data.	File read by PREPRO Effectiveness changes written into by PREPRO.
FACTOR1.	Contains duty position, critical task and factor data.	Read by PREPRO. Changes written into file by PREPRO.
MEN.	Contains manning information.	Read by PREPRO. Changes written in file by PREPRO.
MISSION.	Contains the mission data, e.g., day, type, unit, sequence, platoon activities, end duration.	Read by MISSION. Changes written in file by MISSION.

PARAMET.	Contains the parameter data.	Read by INPUT. Written to file by WFPARA.
E4.	Effectiveness decrement data.	Calculated/written into file by PREPRO. Read by READE4.
NOSEDATA.	Contains internal array including preprocessing.	I/O written into be most subroutines.

The second new element is the PERFECT.DATA which contains copies of each of the input data files. This is intended as a reserve in the case of loss of working data files. For this purpose, the editor is used and the appropriate data split from the file. For splitting purposes, the data are arranged as follows:

1.	EFF1.	lines 21, 278
2.	FACTOR1.	lines 285, 302
3.	MEN.	lines 311, 311
4.	MISSION.	lines 319, 660
5.	PARAMET.	lines 669, 711
6.	E4.	lines 74, 855

To restore a damaged input data file, say PARAMET., first it must be cleared and reassigned.

Enter:
@DELETE PARAMET.↵
@ASG, C PARAMET.↵
Then the editor must be called by entering:
@ED, R PERFECT.DATA↵

Once the prompt is received enter:
SPLIT PARAMET. 669, 711↵

To exit from the editor, enter:
EXIT↵

The third new element PERFECT.NOSEDATA facilitates the printing of intermediate data at Aberdeen. (See Step K. (U1100) #2, this supplement.)

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